April 1974

TIMBER MANAGEMENT

A Programmatic Environmental Analysis Record For Western Oregon

UNITED STATES DEPARTMENT OF THE INTERIOR
Bureau of Land Management
Oregon State Office
P. O. Box 2965
Portland, Oregon 97208

TIMBER MANAGEMENT

A Programmatic Environmental Analysis Record

for BLM-Administered Lands

in

Western Oregon

Department of the Interior

Bureau of Land Management

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PREFACE

The National Environmental Policy Act directs all agencies to prepare a detailed environmental statement on all actions significantly affecting the quality of the human environment. Because all BLM actions affect the environment in some way, each action must be subjected to a systematic method of environmental analysis to determine which actions will require a formal environmental statement.

BLM's timber management program at the national level has been analyzed and found to have significant environmental impacts. As a result, a draft environmental impact statement was prepared for the Bureau-wide program and is now involved in the formal review process.

Analysis of the Bureau's western Oregon timber management program employs a dual approach. First, this programmatic environmental analysis record (EAR) provides a general description of the program and associated management practices, and broadly evaluates the expected environmental effects. Second, this programmatic EAR serves as a basic document supporting, by cross-reference, the supplemental analyses which are prepared for the individual actions which implement the timber management program. Thus the total environmental impact of a given action is expressed in a general way by the programmatic analysis; the supplemental analysis evaluates the anticipated impacts of specific on-site action. In effect, the supplemental analysis complements the programmatic EAR.

Anticipated environmental impacts of unusual character, public interest of high intensity, or other factors, may indicate that a formal environmental impact statement should be prepared for a timber sale or other individual action. However, it is believed that the dual analysis described above will suffice in nearly all cases.

Background

The BLM lands in western Oregon are managed under the terms of the O&C Act of August 28, 1937 which states in part: "The revested Oregon and California railroad grant lands shall be managed for permanent forest production, and the timber thereon shall be sold, cut, and removed in conformity with the principle of sustained yield for the purpose of providing a permanent source of timber supply, protecting watersheds, regulating streamflow, and contributing to the economic stability of local communities and industries, and providing recreational facilities ...."

The mandates of this Act and such subsequent legislation as the Classification and Multiple Use Act of 1964, the National Environmental Policy Act of 1969, and the Water Quality Improvement Act of 1970, require

that these lands be managed for production of timber without detriment to other resources and without degradation of environmental quality.

In order to determine the level of annual timber harvest which meets these mandates, BLM periodically (usually at ten-year intervals) inventories the western Oregon national resource lands and computes an allowable cut. Some of the policies guiding this computation are as follows:

1. Forest lands shall be excluded from the allowable cut where aesthetic, recreational, watershed or other uses have higher priority and are incompatible with timber production.

2. Timber harvest timing and methods shall be modified where aesthetic, recreational, watershed or other uses of higher priority are compatible with limited timber production.

3. A test of environmental feasibility shall be prerequisite to the adoption of any intensive management practice, no matter how economically attractive.

In implementing these policies, the current allowable cut computation includes allowances for the following:

1. The protection of 78 existing recreation sites, as well as 172 areas which have been identified as having future potential for development.

2. The protection of 47 miles of wild and scenic rivers.

3. The preservation of streamside protective corridors on 2,000 miles of streams.

4. The modification of timber harvesting to protect scenic values along 380 miles of roadside corridors.

5. The protection of Research Natural Areas and designated scenic areas totaling 3,000 acres.

6. The protection of 108,000 acres of critical watersheds or fragile soil areas.

7. The special protection of livestock and wildlife forage on 118,000 acres.

The net impact is that the current annual allowable cut for BLM lands in western Oregon is 48 million board feet less than it could be on strictly a sustained timber yield basis. This reduction is the price of the environmental adjustments that have been made.

It is important to understand that the timber management program covered by this EAR is implemented on lands that have been designated as available for timber production after the above mentioned adjustments have been made in the forest land base. As an example, the impacts of logging a potential recreation site are not discussed specifically because such sites have been removed from the allowable cut base and are not available for timber management purposes.

Notwithstanding the aforementioned policies, and despite careful implementation and mitigation, the timber management program on national resource lands still causes adverse residual environmental impacts. These are discussed in section III. of this EAR. BLM considers these impacts acceptable on balance; they are offset by some favorable environmental impacts and by substantial benefits to human society. The BLM timber management program in western Oregon helps to satisfy the growing national need for forest products. It also benefits the region directly, as follows:

1. Approximately 18 percent of the timber cut annually in western Oregon comes from BLM lands. In 1965, this volume translated into 13,500 jobs in logging and processing; $89,500,000 in payrolls and $187,100,000 in value added, including the value of the timber cut.

2. Because of the revenue sharing provisions of the O&C Act, BLM timber management operations in western Oregon result in direct payments to the 18 counties in which O&C lands are located. The magnitude of these payments ranges from 6.1 million dollars in 1952; 21.0 million dollars in 1966 to 47.2 million dollars in 1973. The primary benefits of these payments to the counties are lower property tax levies and better county road systems.

Suggestions for Use

This environmental analysis is intended to give the reader a brief description of the environment in which the BLM timber management operations take place in western Oregon; a discussion of the environmental impacts of the most common practices as they are used; a discussion of the mitigating measures that can be undertaken by the agency, and a discussion of the residual impacts that may be expected. Each of the major headings is further subdivided so that the reader can readily identify impacts on specific components of the environment such as land, air, water, soils, wildlife, etc.

In actual practice, it is envisioned that the scanning of this environmental analysis would give the reader a general feeling for what is involved in the BLM timber management program and a general feeling as to how the environment may be impacted. The reader would then have a background to allow him to look at a specific timber sale or a specific in-place action. The supplemental environmental analysis record associated with the particular action being analyzed would detail for the reader impacts that were over and above those covered in this programmatic EAR or impacts that were unique to the micro-site in which the individual action was located.

I. DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

A. Introduction

The western Oregon public lands consist of nearly 2 million acres or roughly 50 percent of the BLM's nationwide timber production base and are some of the most highly productive forest lands in the nation. These lands produced over 1.2 billion board feet of timber or almost 95 percent of the BLM's total production in 1971 and nearly 20 percent of the total wood harvested from all sources in western Oregon. The primary objective of the timber management program in western Oregon is to produce a high level of raw material from forest lands classified as available for timber production, subject to the principles of multiple use, sustained yield, and environmental quality. In addition to the O & C Act of 1937, which sets forth these basic principles, the program is designed to support the Housing and Urban Development Act of 1968. This law specifies a substantial increase in the supply of raw materials from all Federal forest lands to help meet housing goals. More recently, this same goal was expressed in the President's June 19, 1970 statement which instructed the Secretary of the Interior to "improve the level and quality of management of the forest lands ... to permit increased harvest of softwood timber ... to meet our housing goals." The nationwide need for increasing amounts of forest products has been identified and translated into BLM policy and is contained in BLM Manuals 1602 and 1603.

B. Alternatives

The Bureau-wide programmatic environmental impact statement for timber management discusses three main alternatives for maintaining a timber management program at the Bureau level. These alternatives are:

1. No timber management program. This alternative would be broken down into four sub-analyses: impacts associated with not replacing the unavailable timberland, replacing the unavailable volume from other domestic sources, replacing the unavailable volume by substituting alternative materials in the final utilization stages, and replacing the unavailable volume through the use of imported forest products.

2. Maintaining a timber management program based entirely on natural production levels. In this alternative, timber growth, and consequently timber yield, is regulated by the forest's natural ability to reproduce itself following harvest without any cultural or artificial treatment by man.

3. Timber management program with intensive forest practices. In this alternative, the level of yield is governed by the ability of the forest to respond to various cultural and management practices aimed at taking advantage of or increasing natural forest productive capacity.

At the present time the State Director is not faced with choosing one of the above mentioned alternatives. This decision has been made at the policy making level and the guidelines contained in the forestry program activity policy statement (BLM Manual 1603) and other directives indicate that BLM lands in western Oregon are to be managed for maximum yield, commensurate with multiple use and environmental considerations, using intensive management practices. Thus, Alternative #3 is the proposed action which will be analyzed in the remainder of this document.

Given the fact that the overall thrust of the timber management program has been set by policy directives, the job at the district and state levels is one of choosing between numerous operational practices and management alternatives in implementing the timber management program on the ground. The purpose of this analysis is to describe, in a general way, the existing forest environment in western Oregon, the most common management practices that are used, the general impacts of these management practices, and ways in which these impacts can be mitigated. This programmatic analysis must be complemented by a further analysis of each proposed timber management action, and by a supplemental EAR applicable to the particular proposal.

It is important to remember that the timber management program for a given planning unit is not developed independently but is a product of the Bureau Planning System. Under this system, land use plans are referred to as Management Framework Plans (MFP). The MFP for a specific forest describes the various resource uses which are permissible in the area after consideration of the applicable guidance, the technical data about the resources and resource uses, the needs of the public, and other inputs to the decision making process. In addition, it describes the constraints on the planning for the utilization of those resources which are necessary to insure compatibility of uses, protection and enhancement of the environment, stability of dependent communities, and other objectives of management. The Management Framework Plan is prepared by an interdisciplinary team at the field level, working in close coordination with a variety of groups and interests in an organized public participation process. Following the approval of the MFP, program activity plans are then prepared for each resource.

The timber management program is thus an activity plan which lays out how the timber resources will be managed to achieve the objectives and to meet the constraints shown in the Management Framework Plan. It is important to note that it is impossible to determine the full range of coordination and mitigative effort relating to environmental matters that have occurred in the planning process by referring to the timber management plan alone. The timber management activity plan details the program that will be carried out after adjustments and constraints have been imposed as a result of blending the timber inputs with multiple use and environmental considerations in the Bureau planning process. As an example, the timber management activity plan details the efforts that will be made for environmental protection of lands available for timber production. However, the Management Framework Plan may have already

removed areas of timberland from consideration for timber production because of environmental or multiple use considerations. Thus, in order to get a complete picture of both environmental impacts and mitigative efforts, it is essential to view the planning process as a whole and not merely concentrate on the activity plan itself.

C. Stages of Implementation

The implementation of the timber management program in western Oregon occurs in four generalized stages. These stages of implementation are described as follows:

Inventories

The two types of forest inventories are (1) intensive, and (2) extensive.

1. Intensive inventories appear in the timber subsection of the Unit Resource Analysis (URA). The URA is part of the information gathering and analysis portion of the Bureau Planning System; it provides a summary inventory and analysis of available data on all resources within a planning unit. The inventory includes a classification system that identifies the commercial forest land base capable of producing timber on a sustained yield basis. This system identifies and excludes from the timber production base (a) lands which are so fragile that timber management practices cannot be applied without causing serious degradation of the timber production capabilities, and (b) lands having reforestation problems so severe that they cannot be restocked to BLM standards within acceptable time limits. The system also identifies areas that may be managed for timber production but must be restricted to specific silvicultural, engineering, or other practices to protect fragile sites or insure acceptable reforestation. Non-problem areas capable of receiving intensive forest management are also identified. These, combined with restricted areas described above, constitute the timber production base for the allowable cut computation.

   Intensive inventories also include a classification system that identifies, within the timber production base, units conducive to specific types of intensive forest management practices such as thinning, mortality salvage, and fertilization. These areas are identified according to criteria such as in-place stand condition, volumes, growth rates and site classes.

2. Extensive inventories sample commercial forest land for volume and growth rates in order to calculate the allowable cut. Only data taken from lands determined by the intensive inventories process to be in the timber production base are used to calculate the allowable cut.

Coordination with the MFP

As mentioned above, portions of the planning unit land base that are suitable for commercial forest production are identified in the URA and in Step 1 of the MFP process which lists the activity recommendations for full timber production. In subsequent steps 2 and 3 of the MFP process, this activity recommendation is tempered by policy, environmental considerations, and multiple use trade offs. This results in a generalized zoning of the planning unit which identifies portions of the commercial forest land base which are available for intensive timber production, portions of the commercial land base on which management practices must be tempered because of environmental or multiple use considerations, and portions of the commercial forest land base which are not available for timber production because of the same considerations. It is at this step in the process that some of the most important mitigative efforts in terms of environmental protection are taken. It is important to understand this process entirely before going on to look at the timber management activity plan itself.

Allowable cut computations

At this stage, the technical input from the forest inventory is blended with the managerial considerations developed in the MFP to determine what level of activity will provide the maximum yield of forest products consistent with sustained yield principles and with the multiple use recommendations contained in the MFP. The allowable cut plan details not only what levels of harvest are to be carried on, but also lists what intensive management practices must be accomplished on a decade basis to support this level of harvest. It is stated Bureau policy that intensive practices, no matter how technically or economically feasible they may be, are not to be included in the allowable cut plan unless they meet adequate environmental standards. For a detailed summary of the allowable cut computation process, refer to BLM report "An Allowable Cut Plan for Western Oregon" dated March, 1970. For details on the level of activity in the management practices being used, refer to the allowable cut plan printout for the individual planning unit under consideration.

Timber sale plan

This stage involves blending the technical mandates of the allowable cut plan with the multiple use and environmental recommendations of the Management Framework Plan to arrive at an operating plan for the timber management activity. Stated simply, the thought process used involves first identifying those tracts included in the timber production base which, based on technical forestry considerations, have a priority for immediate harvest. After the location of these tracts has been determined, the planner then checks with the MFP to determine what constraints and considerations are indicated for timber management activities in the particular area. These constraints and considerations form the basis on which the planner will design the layout of the harvest area and will

determine what standards are to be used in harvesting and roading the area. The implementation of the timber sale plan is described as follows:

1. Plan formulation on a fiscal year basis. The tracts identified by the thought process described above for a particular planning unit comprise the timber sale plan for that year. The plan as prepared must meet the recommendations set out in the MFP. The proposed timber plan is exposed for public comment both by dissemination to interested parties and by exposure to the district advisory boards representing various segments of the public. Copies of the timber sale plans for all western Oregon planning units are also sent to the State clearinghouse where they are reviewed for any possible coordination needed with planned activities of other agencies or governmental bodies.

2. Sale layout. After the timber sale plan has been reviewed and approved, the individual tracts listed are designed and laid out in the field. The design of these particular tracts, including such things as size, road locations, logging methods, whether or not buffer strips are left, etc., is guided by the recommendations eminating from the URA and MFP. Sale layout is a crucial step in seeing that the intent of the MFP is carried out in the individual on-the-ground application of management decisions.

At this point in the process, the individual timber sale is advertised and sold. This begins the cycle of harvest, regeneration of a new stand, cultural measures applied to the new stand, and protection of the new stand until such time as the stand again undergoes a final harvest cut. The management practices used in this cycle and their respective environmental impacts are described in the remainder of this document.

D. Harvest

Harvest is the final phase of the timber production cycle and the first phase of the utilization cycle, which converts standing trees into forms useful to the economy and arts. The steps associated with these phases of the production or utilization cycles include the felling of marketable timber according to selected cutting practices, the movement of logs or trees from stump to loading points by use of logging systems, and their subsequent movement over transportation systems to manufacturing centers.

Cutting Practices

Selection of the appropriate cutting practice is basically a matter of silvicultural desirability; i.e., a certain practice, or combination of practices, is applied to a given timber stand in order to favor regeneration and/or promote growth. Factors weighed in selecting the cutting practice include species composition; stand age, stocking and condition (as related to tree vigor and risk of mortality); site quality and regenerative capacity; fire and insect hazards which may be created by logging slash; topography; and anticipated effects of weather conditions on the residual stand. Consequently, because of the diverse nature of conditions within a given forest, a variety of cutting practices is employed. Once the cutting practice(s) is chosen, those trees designated for cutting and/or trees reserved from cutting are identified on the timber harvest area.

Cutting practices have been classified by different authorities in various ways; e.g., as silvicultural systems for obtaining natural reproduction by several means and by nomenclature descriptive of the action taken. A practical classification (for the purpose of this subsection) lists cutting practices in two major categories, intermediate cuttings and final harvest cuttings, as follows:

—Intermediate Cuttings. These are practices applied prior to the major or final harvest of a stand, with the qualification that trees designated for cutting have commercial value.

—Commercial Thinnings (P. 1A). Various types and intensities of cutting applied to immature stands for the purpose of redistributing growth on the uncut trees, to recover and use material that otherwise would be lost, and thus to obtain greater total yield of merchantable material. Dependent upon the age of the stand and other factors, commercial thinnings are conducted at prescribed intervals over the life of the stand.

—Sanitation-Salvage Cuttings (P. 1B). These are made to remove individual trees killed or injured by fire, insects, disease, etc., and those trees likely to die prior to the final harvest in order to prevent the spread of insects or disease, and to utilize merchantable material before it becomes worthless. Trees cut may be immature or mature, but tree condition, not age, is the criterion for removal.

—Shelterwood Cuttings (P. 1C). Removal of mature timber from a stand in a series of cuttings which extend over a period of years. In theory the series is divided into three stages. In actual practice, the mature timber may be removed in a single cut or in a series of as many as ten cuts, depending on stand conditions and management prescriptions. The three stage cut is most common, however, and it is the practice described and analyzed here. Two stages are herein classified as intermediate cuttings and the third as shelterwood removal, which is described under the final harvest cuttings:

- Preparatory cutting prepares the stand for seed cutting by removing dying and defective trees and trees of undesirable species.

- Seed cutting prepares the seed bed, opens the stand to provide light and heat that the expected seedlings will require, and encourages seed production.

Final Harvest Cuttings. In contrast to intermediate cuttings, which include immature trees, final harvest cuttings usually remove only trees which have reached maturity.

—Clearcutting (P. 2A). Removal of the entire stand in one cut. This practice is commonly applied to even-aged stands, in which most of the individual trees achieve maturity simultaneously. Species which constitute such stands; e.g., Douglas-fir, are more or less intolerant (light demanding), and are usually effectively regenerated by clearcutting. Salvage of extensively damaged stands may also result in the clearcutting of uneven-aged stands. Disease infection in timber stands often requires clearcutting to remove sources that would infect young trees in the new forest.

—Seed Tree Cutting (P. 2B). Removal of the mature timber in one cut, except for seed trees (reserved for stand regeneration) left singly or in small groups. These seed trees may be subsequently cut when the area is reforested.

—Selection Cutting (P. 2C). Removal of mature timber, usually the oldest or largest trees, either as individual trees or in small groups at relatively short intervals, commonly 5 to 20 years, repeated indefinitely while the continuous establishment of natural reproduction is encouraged and an uneven-aged stand is maintained.

—Shelterwood Removal Cuttings (P. 2D). These represent the third and final phase in a series of shelterwood cuttings as previously described under intermediate cuttings. They remove the remainder of the mature stands which would, after establishment of reproduction, retard the development of young trees. The final cutting is the last of the removal cuttings.

Logging Systems

The movement of felled timber from the stump to the loading point (landing) is accomplished through the use of a single system or combination of logging systems best suited for the area to be harvested. The selection is based on criteria which include:

- The physical characteristics of the area and capabilities of the applicable logging systems.

- An economic evaluation of various combinations of logging and transportation systems.

- Silvicultural needs of the area and cutting practices to be employed, and the priority sequence of harvesting.

- Protection of the reserve timber stand and preservation of soil and water resources.

- The safety of the men engaged in all phases of the harvesting operation.

- The requirements and goals of multiple use management.

While outside the scope of logging systems, the cutting or falling of trees and bucking them into tree or log lengths requires some mention at this point. These operations are a prerequisite to their movement and constitute a major part of the logging operation. Trees are normally felled in a manner which minimizes loss due to breakage as well as damage to the residual trees or adjacent stands. Beds are sometimes prepared to reduce breakage when very large trees are cut. In addition to topographical criteria, the system of logging to be employed is a factor in the manner and direction in which the trees are felled. In both the falling and bucking operation the chain saw is the common tool.

The various logging systems presently employed can be broadly classified as ground systems or aerial systems.

Ground Systems. These systems can move logs only by dragging (skidding) them along the ground. These are often called "conventional" systems because they were the means originally employed and continue to be more widely used than aerial systems. Following are brief descriptions of some ground systems used in logging operations.

— Horse Skidding (P. 3A). Horses are still used advantageously in some situations. On suitable terrain they are well adapted to skidding small logs such as those produced in commercial thinnings. Horses can be used on narrow skid trails with minimum damage to the residual stand. They are best suited to skidding small logs down slope on gradients under 40 percent, for maximum distances not exceeding 600 feet.

——Tractor Skidding (P. 3B). Logging tractors are of two general types, crawler and wheel. The former has a metal track while the latter are invariably mounted on rubber and are known as rubber-tired skidders. Both types are sometimes used to draw track-mounted arches or rubber-tired sulkies, or are equipped with integral arches. These accessories suspend one end of the log or turn of logs, thus reducing drag.

Both types of tractor are used most effectively for downhill skidding on slopes under 35 percent, and for maximum distances less than 1500 feet. Uphill skidding for short distances is feasible on gentle slopes, particularly for the larger crawler tractors. Often tractors complement other systems. A combination sometimes used on sidehill settings is downhill tractor skidding of the upper part and uphill high-lead yarding of the lower part to the same roadside landing.

——High-lead Yarding (P. 3C). (See Figure No. 1). Despite the increasing application of newer, alternative equipment to logging situations once operable only by high-lead, it remains one of the most important of the moving-cable systems. There are sound reasons for its popularity since many forested areas are too steep, broken or rocky for tractors. On clayey soils tractor operations are frequently impossible or too damaging to the site during the rainy season.

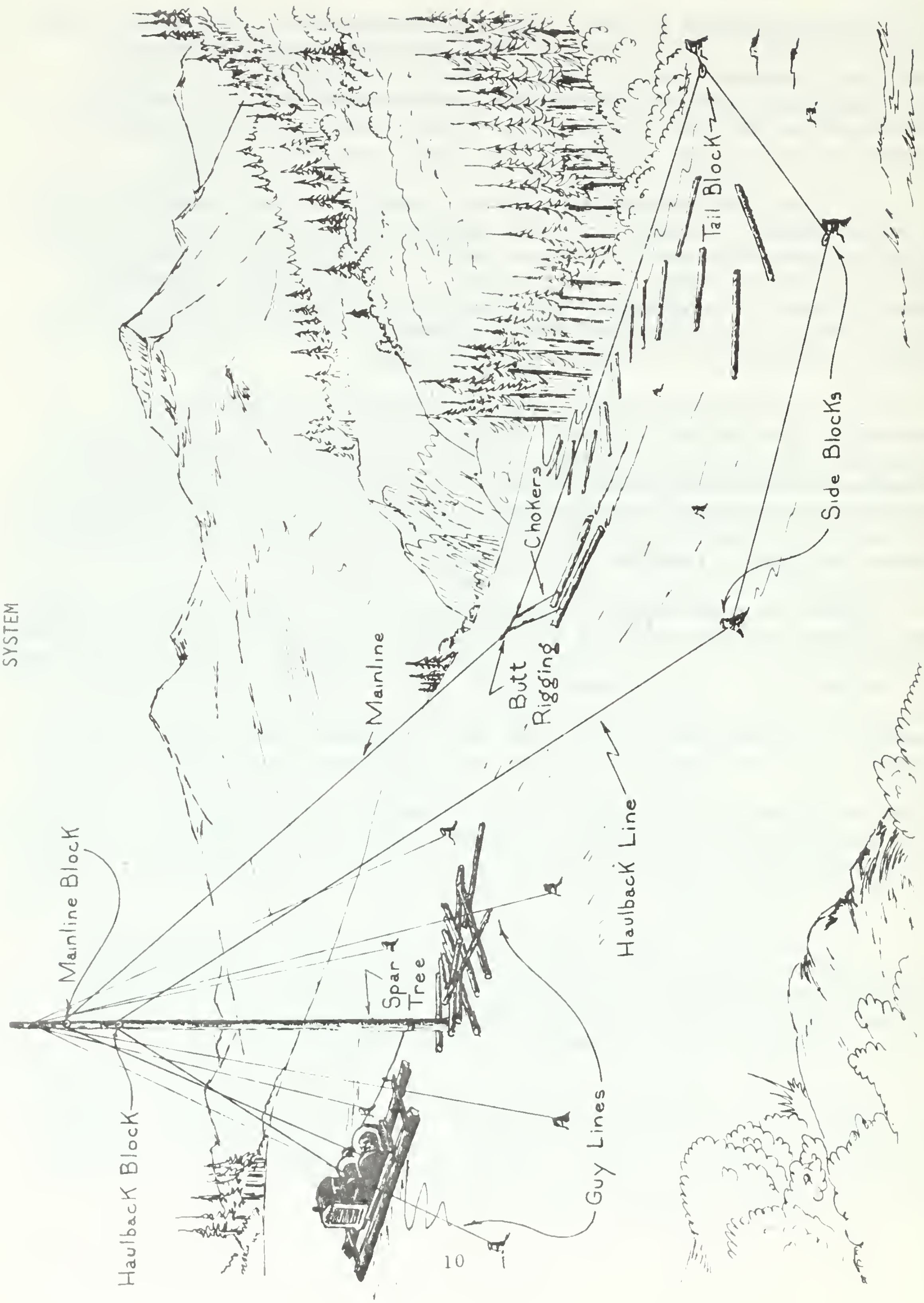
Rigged for use, the power source (yarder) is anchored at the landing near a vertical spar (usually 80 to 120 feet tall) which provides lift for the turn of logs. As the mainline yards the logs toward the landing, they are dragged full length along the ground. If a stump or other obstacle is encountered, the vertical component of force on the mainline lifts the front end of the log until it noses over or around the obstacle. Consequently, the high-lead system operates most smoothly and efficiently when yarding uphill. Downhill yarding is feasible, but logs tend to "hang-up" on obstacles and dig into the ground. When all logs within reach of the mainline are at the landing it is moved laterally. The process is repeated in radial fashion, with the spar as a hub, until all desired logs in the setting have been moved to the landing.

The high-lead system is best adapted to yarding clearcut settings uphill, with maximum yarding distance of about 800 feet as optimum, although longer "reaches" are possible. With careful operation by a skilled crew, the system can also be used for logging such partial cuts as sanitation-salvage, shelterwood and selection cuttings.

——Mobile Yarder-Loader Operations (P. 3D). Various methods of yarding are employed in situations where neither high-lead nor tractor logging is practical. The mobile yarder-loader is particularly adapted to removing small total volumes of timber, to operating in stands of low volume per acre, or in small timber on steep terrain.

FIGURE NO. 1

HIGH-LEAD YARDING SYSTEM



While there are several variations of mobile yarder-loaders, they have certain common characteristics:

- All are self-propelled, and can be driven from setting to setting (as opposed to most high-lead yarders).

- All are equipped with booms or spars which, when erected, provide lift for yarding. When lowered, the boom can be rigged for loading trucks, thus eliminating a separate loading machine.

- Most have drum facilities which permit being used as high-lead systems.

Some of these machines can yard logs to a reach of 1000 feet. However, under optimum conditions, usual maximum yarding distance is about 500 feet. Since they operate on the high-lead principle, mobile yarder-loaders are most efficient when yarding uphill.

These machines are well-suited to logging commercial thinnings, and sanitation-salvage, shelterwood and selection cuttings. A rather unique attribute is their capability of operating directly from an existing road, thus eliminating the necessity of clearing and excavating landings. As each small setting below the road is cleared of logs, which are merely piled or "decked" along the road shoulder, the machine is quickly moved a short distance along the road to its next setting.

—— Other Ground Systems (P. 3E). Jammers and self-loading trucks are sometimes used for yarding, principally in small logging operations.

- The <u>jammer</u> (usually a homemade machine) employs an erectile boom and an engine-powered drum, on which is wound a wire-rope cable used for both yarding and loading. While basically a machine for loading trucks, the jammer may be used for yarding logs for relatively short distances (usually not exceeding 300 feet). On slopes too steep for tractor operation, the jammer's limited yarding capability can be useful with a system of roads on contours spaced at slope distances of 600 feet or less.

- The <u>self-loading</u> truck is commonly equipped with a short horizontal boom with fairlead, and cable wound on a drum powered by take-off from the truck engine. Under favorable conditions, such trucks can yard logs from locations within 100 feet of roadside.

Both jammers and self-loading trucks tend to perform poorly as yarding machines because of low line speeds. Consequently, they are rarely used as such in operations requiring high yarding production.

Aerial Systems. These are capable of moving logs suspended above the ground from stump to landing. Suspension may be complete or partial; i.e., logs can be suspended free of the ground (known as "flying" the logs) or one end of the log may drag. The advantage of any of the aerial systems over more conventional systems is their ability to move logs with an absolute minimum of disturbance to soil and water resources. The three major types of aerial systems currently operational are skylines, balloons and helicopters; these are discussed separately.

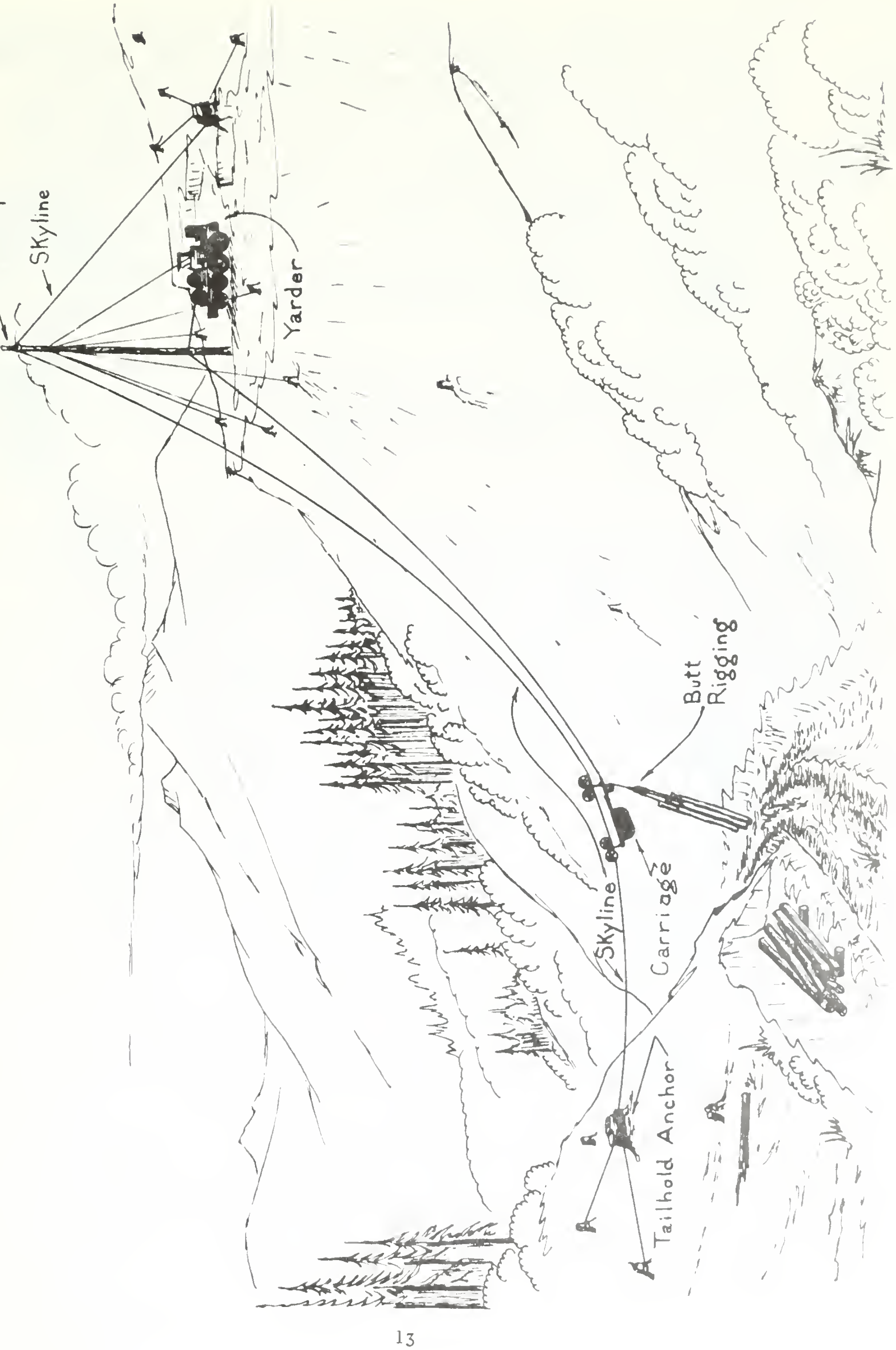
—Skyline Yarding (P. 4A). Skylines are moving-cable systems which yard or swing logs suspended between a tail-spar and a head spar. The basic principle of movement is via suspension from wire-rope cables. Modern skyline systems are mobile and have lateral yarding capability. The newer systems can be used for both uphill and downhill yarding. Some are readily convertible to conventional high-lead operation, a feature which increases their utility. Modern skyline systems are of three general types; standing or fixed skylines, slacklines, and running skylines:

- Standing (fixed) Skylines. (See Figure No. 2). The operating range of the larger fixed skyline equipment is very great; maximum yarding distances of 5000 feet are possible. This potential, properly utilized, can greatly reduce the road density which would be necessary for logging a given area by conventional means. The larger standing skyline equipment is best adapted to logging larger clearcut settings of heavy timber volumes per acre, in rough topography or on fragile sites where the expense or environmental risk of developing intensive road networks would be prohibitive.

  Smaller fixed skyline equipment with yarding capability of 1500 to 2000 feet is available. These machines and rigging are less costly and more flexible than the large skyline-cranes. Properly used, they are adapted to some partial cuttings as well as clearcuttings. While they do not offer the road construction cost-saving potential or site protection potential of the larger skylines, they do have an advantage in these respects over the high-lead and tractor systems.

- Slacklines ("live" skylines). Commonly operating on a reach of 1200 to 1600 feet or more, slacklines have capabilities and applications comparable to those of the smaller fixed skyline systems.

STANDING (FIXED) SKYLINE SYSTEM



- Running Skylines. (See Figure No. 3). These are the most recently developed of the skyline systems. They are becoming widely used in the northwestern United States, and are replacing standing skylines and high-lead systems in some applications. A past disadvantage of these systems has been a rather short span capability (reach) of about 1000 feet. However, yarders with reaches exceeding 2000 feet are now available. The running skyline is particularly well-suited to yarding intermediate cuttings and harvest cuttings of a partial nature, where damage to trees left standing must be minimized. Properly equipped and utilized, running skylines may yard clearcuttings as effectively as the high-lead.

—Balloon Yarding (P. 4B). (See Figure No. 4). Despite rather wide publicity, balloon logging has had only limited use to date. The few American balloon logging operations conducted to date have probably been economically marginal. Applications in coastal British Columbia have been more successful.

Balloon systems, which lift logs completely off the ground, have yarded for distances exceeding 5000 feet, although 3000 feet might be considered optimum. Balloon systems are more expensive to operate than skylines because of additional costs of the balloon, its accessories, and gas for inflation. Other disadvantages are instability of the balloon in moderate to strong winds, adverse reactions of the balloon to temperature extremes, and gas leakage. The increased expense of balloon logging may be justified where terrain and limited road access preclude logging with other systems, or where ability to remove logs with a minimum of surface disturbance is needed to protect a fragile site.

Presently, balloon yarding appears to be best adapted to clearcuttings because of the difficulty of controlling the balloon in side winds and resulting lateral movement of the butt rigging and its suspended turn of logs, which can damage reserved trees in a partial cut. However, experience indicates that the balloon can be used successfully to remove the overstory of a two-storied stand.

—Helicopter Yarding (P. 4C). Helicopter logging applications are in the formative stages. The very high unit costs of yarding with helicopters are the primary factor now limiting the use of these machines. However, high performance helicopters capable of lifting maximum loads of 20,000 pounds are available for logging.

In a well-planned helicopter logging operation, one-way flight distances should range from 1300 to 5000 feet. The logs are hooked to a tag line 100-200 feet in length which is suspended from the helicopter, which then climbs vertically to clear obstructions before moving toward the landing.

FIGURE NO. 3

RUNNING SKYLINE SYSTEM

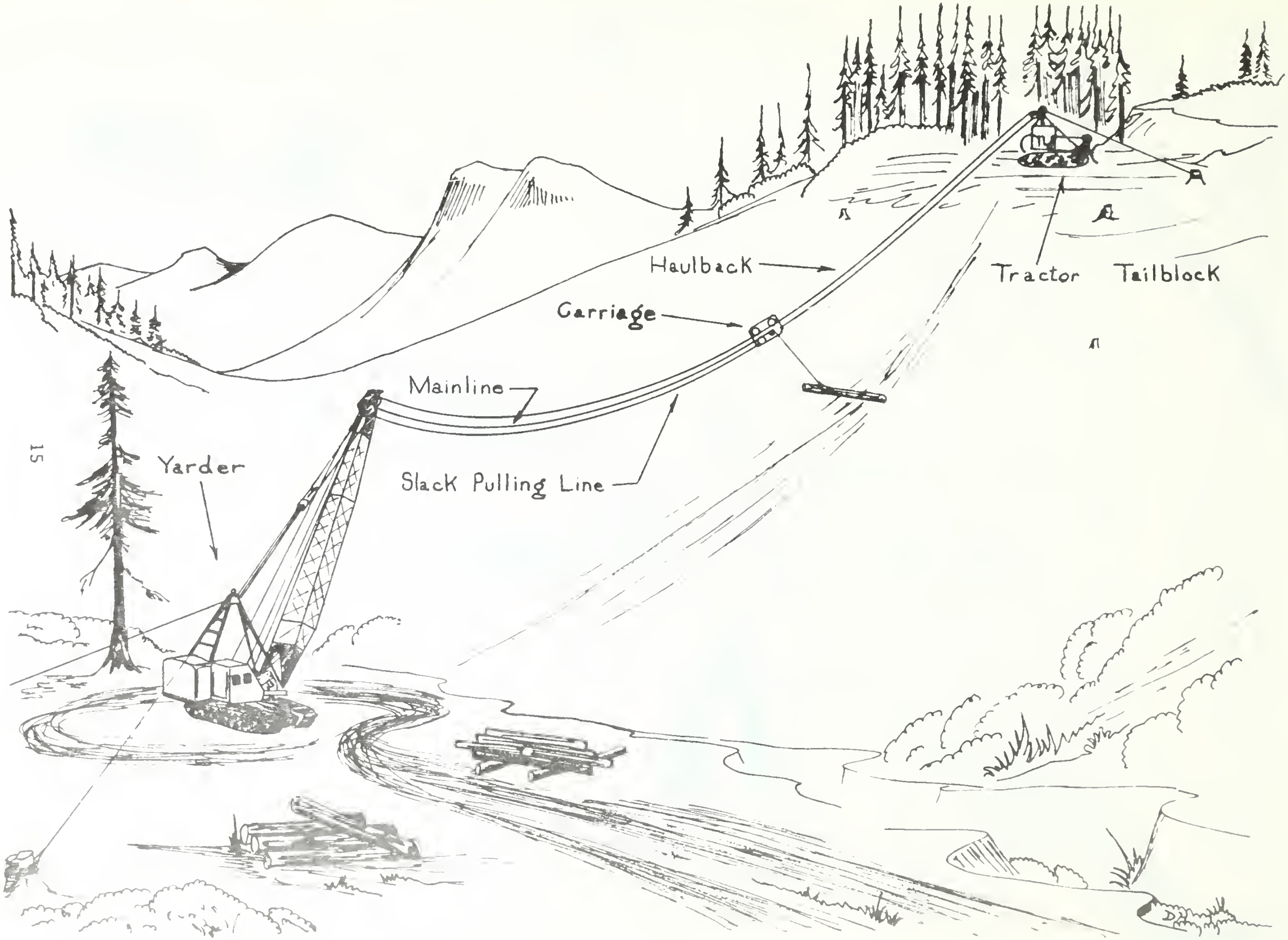
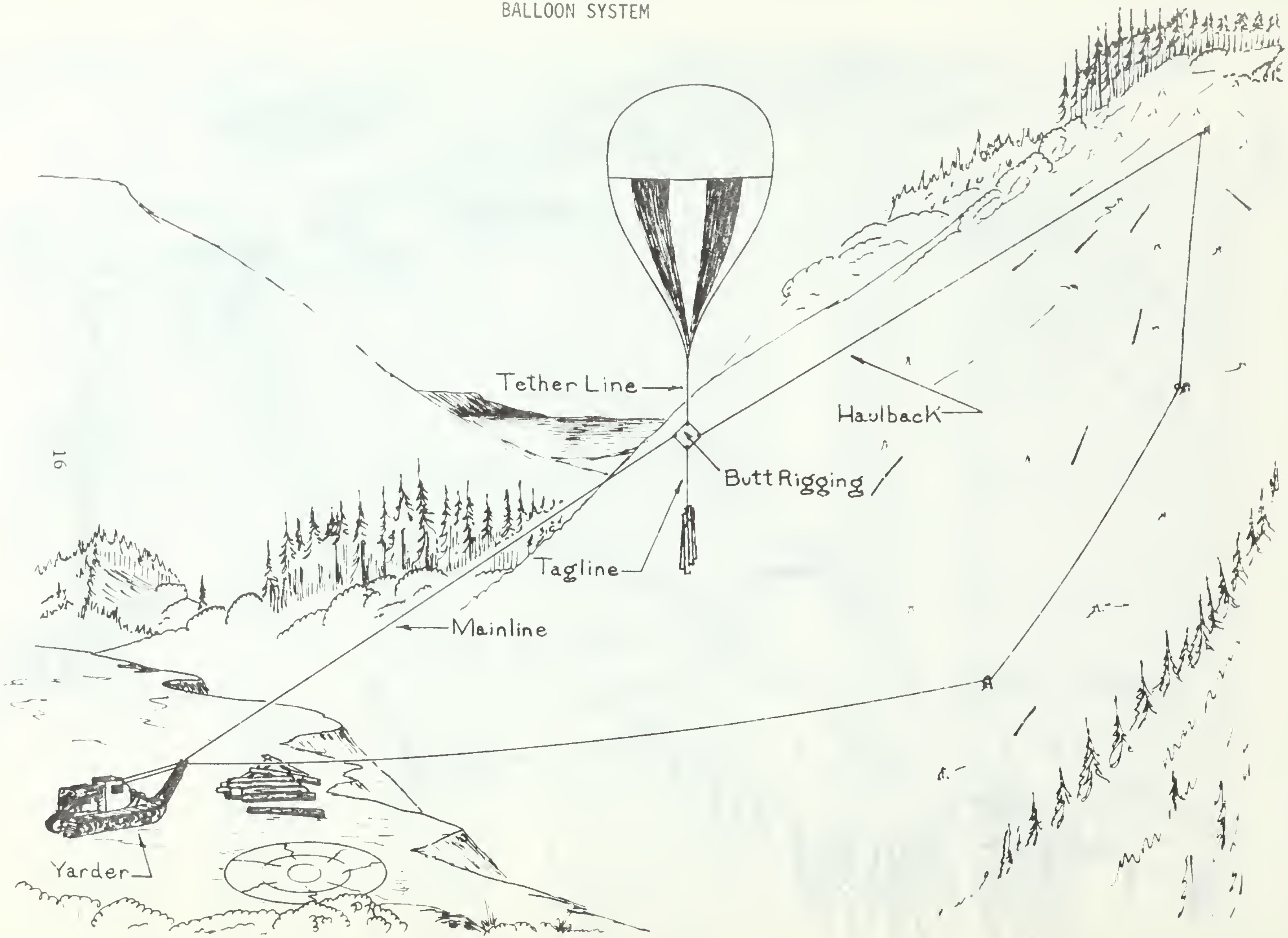


FIGURE NO. 4

HIGH-LEAD RIGGED
BALLOON SYSTEM



Areas to be partially or selectively logged can be yarded by helicopter in cases where the surrounding trees or residual stand are not too tall. The removal of overstory timber to release young trees may present good opportunities for helicopter logging.

Transportation Systems.

The primary purpose of transportation in the context of timber management is to provide a medium for moving logs from the landing or loading site located in the cutting area to a market destination which may be a few miles to a 100 miles distant. The major mediums currently in use are land transportation and water transportation. The former consists of hauling the logs over a road and/or railroad system while the latter involves the utilization of water to transport the logs. Since rail transportation is not used in moving logs on Bureau timber sale areas, and does not appear to hold promise in the future, it will not be discussed.

Water transportation includes the floating, rafting, or barging of logs on such natural waterways as rivers and lakes. Currently this method of transportation is not commonly used in moving logs from Bureau administered lands in western Oregon; therefore water transportation will not be discussed further in this statement. Related to this matter is the use of water to store logs somewhere enroute to a manufacturing facility. At the present time the Bureau is involved with one log storage dump, located on the Smith River in the Coos Bay District. Since an environmental impact analysis has been made of this operation entitled, "Operations of the Smith River Log Dump as Related to Water Quality and Aquatic Resources," October 1972, it will not be included in this statement.

The dominant transportation medium currently in use is the hauling of logs by trucks over roads. Because of intermingled land ownership patterns, the development of road systems often requires cooperation with adjacent landowners to insure access to the local, state and Federal highways that lead to the manufacturing centers.

When substantial lengths of road are to be built under the terms of a timber sale contract, or when planned road construction requires the acquisition of an easement across private land, a separate environmental analysis is commonly done on the alternative road locations.

While Bureau roads serve other forest values and uses, the cost of construction and maintenance is usually carried by the timber resource and is provided for under the terms of the timber sale contract. Consequently, the time of construction is usually scheduled in conjunction with the sale of a given tract of timber. Specific construction phases are determined by environmental and multiple use management considerations. Once constructed the roads can be used for forest protection and other activities associated with the timber management program as well as recreation.

The width and upkeep of these roads varies with the type of use, topography and other variables. However, they generally range from 14 to 20 feet in usable width and 40 to 100 feet across the cleared area. Not all roads are part of the permanent road network. Some are used for a given period of time and then abandoned.

The operational practices associated with the development of the transportation system are included under the construction and maintenance phases and will be discussed on that basis in the following sub-sections.

Construction. This phase includes all the practices followed from the initial entry of equipment on the road location site to its availability for log hauling. The construction phase involves the movement of a portion of the earth's surface from one location to another and in its new position, creation of a desired shape and physical condition which will serve the purpose for which the road is built. While roads are of varying standards and specifications, the practices set forth are characteristic of those constructed on Bureau administered lands.

Basic construction operations are clearing and grubbing, excavation, formation of embankments, finishing and addition of bases and surfacing courses, and structures. Any or all of these operations may be performed on a given road project at the same time and may overlap to a certain extent.

—Clearing and Grubbing (P. 5A). Clearing refers to the removal of trees, brush, etc., from within the limits of the designated area along the road's location. Grubbing refers to the removal of roots, stumps and similar obstacles to a nominal depth below the existing ground area. Frequently, they comprise a single operation and include the removal of topsoil to a shallow depth. This practice is primarily performed by a bulldozer to fell trees and uproot stumps, however it may also involve the use of explosives and other equipment.

—Excavation (P. 5B). This practice refers to the removal of natural material from its resting place and transporting it to a different place through an earth moving operation. It normally constitutes the major part of the construction operation and, in addition to the road itself, is carried out in conjunction with the installation of such structures as culverts, drainage pipes and bridges. Excavation may be classified by the type of material excavated, as follows:

- Topsoil excavation is removal and stripping of the exposed layer of the earth's surface.

- Earth (or common) excavation is removal of the layer of soil under the topsoil and on top of rock. Earth can be broken down for ease of handling by plowing and ripping and is usually moved easily by scrapers or other types of earth moving equipment.

- Rock excavation is the breaking down of a formation by systematic drilling and dynamite blasting, for ease of removal by rockhauling equipment.

- Muck excavation is removal of soil that contains an excessive amount of water. This material is unstable under loading, and is undesirable as embankment or subgrade material.

- Unclassified excavation is done without regard to materials encountered and may be any combination of topsoil, earth, rock, and muck.

The equipment most widely used in excavating work is a wheel or track (crawler) type tractor with a steel blade that can be raised and lowered. Equipped in this manner a tractor can push material from place to place and shape the ground. Tractors can also be attached to scrapers for excavation and short hauls, however trucks or self-propelled scrapers are usually used when earth is to be moved any distance.

—— Embankment (P. 5C). This practice represents the construction of roadway embankments, including preparation of the areas upon which they are to be placed; the construction of dikes within or adjacent to the roadway; the placing and compacting of approved material within roadway areas where unsuitable material has been removed; and the placing and compacting of embankment material in holes, pits, and other depressions within the roadway area. When available excavation material is not sufficient for the embankments, borrow material from outside must be brought in.

In some cases embankments may be required to be constructed in layers, the thickness of which varies. Compaction of each layer is by steel rollers, rubber-wheel rollers, sheepsfoot rollers, etc. which may be self-propelled or towed by a tractor.

—— Finishing (P. 5D). This practice is performed primarily by a motor grader and includes such items as trimming and finishing of slopes and the fine grading operations required to bring the subgrade to the final desired elevation.

—— Bases and Surface Courses (P. 5E). This treatment consists of all or part of a flexible pavement which is usually made up of a wearing surface, bases and subgrade. The wearing surface is usually made up of a macadam, bituminous surface treatment or gravel surface and must withstand wear, abrasion and displacement from vehicles and prevent water from entering the base of the roadway. The bases are usually constructed of gravel or crushed rock and are layers of very high stability and density. The subgrade is the natural earth surface. In the usual

instance it is the compacted soil in a cut section or the upper layer of an embankment section. Stone for use in the bases and surface course is obtained from nearby quarries or crushing plants.

—Structures (P. 5F). These consist primarily of bridges, culverts, cattleguards, fences, retaining walls, guardrails and riprap. These structures may require excavation, embankment, concrete work, backfilling, or other construction operations.

Maintenance. This phase includes the necessary repairs to keep a road in a safe, serviceable condition for use by logging trucks and passenger cars.

—Surface Maintenance (P. 6A). Dirt road maintenance is primarily blading and leveling and cleaning out of the side ditches and culverts.

Gravel roads which are untreated require a heavy blading of the surface and side ditches in early spring and late fall. Heavy rains may cause deep rutting and require additional gravel and blading.

Road mix and macadam surfaces require patching of holes, ruts, and raveled areas, and renewal of the surface periodically by application of a seal coat.

—Shoulder, Sideslope and Roadside Maintenance (P. 6B). This maintenance consists of erosion control, visibility protection and brush control. The erosion control is accomplished by seeding and mulching and other soil stabilization practices and the brush control is accomplished by cutting back (or chemically treating) weeds and brush which obscure visibility and interfere with drainage.

—Drainage Maintenance (P. 6C). This is accomplished by removing debris from culverts, correcting erosion by use of rock backfill, repairing eroded ditches with rock material and riprapping areas eroded by stream action. This also includes repairs to bridges and small structures.

—Safety Maintenance (P. 6D). This includes sanding icy sections, replacing signs and protective barriers in order to preserve safety features of the original construction, dust prevention by spreading oil or water, debris removal and some limited snow removal.

E. Development

Practices included in the development phase of the timber management program are primarily aimed at (1) re-establishing trees on forest land following harvest or natural catastrophies, and (2) insuring satisfactory or optimum growth of these forests. Actions directly associated with timber harvest, such as cutting practices designed to provide regeneration through natural seeding, are discussed in Part A, Harvest, even though they bear upon the questions of re-establishment and growth. The individual practices listed below are in the general order in which they might be carried out on the ground; although several may be accomplished simultaneously. Furthermore, not all of these practices are carried out on a given area. Many of the practices represent alternative methods, the choice of which is dependent upon the conditions on the area.

Tree Improvement (P. 7A).

Tree improvement programs are developed to optimize specific genetic characteristics such as growth rate, or resistance to disease. Major efforts to date involve (1) development of fast growing Douglas-fir and ponderosa pine, and (2) development of sugar pine trees resistant to white pine blister rust. The program provides genetically improved tree seed or seedlings for use in reforestation activities.

Tree improvement programs require development of (1) centrally located "seed orchards" where genetically improved seed can be produced, and (2) "progeny test areas" where improved seedlings can be grown and measured. Development of these areas often requires harvest of timber on selected sites followed by cultivation to prepare the site for planting. Cultivation methods used may include one or more of the following described actions.

High values associated with seed orchards and progeny test areas often require control of insects and disease with insecticides and fungicides. Such pesticides may be applied using hand compression sprayers, gas bombs, injection or tractor drawn ground sprayers.

Scarification (P. 7B).

Heavy machinery such as crawler tractors, equipped with toothed brush blades are used to uproot woody vegetation and to pile it for burning, decomposition or disposal by burying. This measure is taken to prepare the site for seeding or planting by exposing mineral soil, conserving soil moisture, providing sunlight, destroying habitat of seed or seedling eating animals and/or guarding against fire.

Mechanical Brush Cutting (P. 7C).

Heavy, tractor-drawn "brush-cutters" may occasionally be used on site to chop and crush woody vegetation and debris in order to hasten decomposition in preparation for seeding or planting. Hand lopping and scattering is another method by which slash is put in direct contact with the ground.

Mechanical Trenching - Furrowing (P. 7D).

Tractor-drawn implements may occasionally be used to construct furrows, trenches or cleared spots in herbaceous vegetation prior to seeding or planting.

Area Burning (P. 7E).

This commonly used treatment involves movement of one or more relatively continuous lines of fire over several contiguous acres for the purpose of destroying woody vegetation and debris, such as logging slash. Burning may also require pre-treatment with a chemical such as Picloran (Tordon 101) to dry woody vegetation prior to burning. Burning is useful in preparing a site for reforestation, reducing potential fire hazards, and/or protecting existing stands by destroying material infected with insects or disease.

Spot Burning (P. 7F).

Piles, or concentrations, of woody vegetation and debris (such as logging slash or slashings from precommercial thinning or pruning) are destroyed by burning for the same purposes listed above.

Burying (P. 7G).

Logging slash or debris resulting from scarification treatments may occasionally be buried in pits constructed by heavy equipment such as crawler tractors for the same purposes as broadcast burning.

Chipping (P. 7H).

Logging or thinning slash is sometimes handled by chipping it and disposing of it on site or other suitable disposal areas. In some instances the chips are transported to a utilization facility for processing.

Hand Clearing and Cleaning (P. 7I).

Hand tools (such as hoes, axes, and power saws) are often used to clear individual planting or seeding spots of vegetation and debris, or to remove competing vegetation from existing trees.

Seeding (P. 7J).

In field seeding operations, as opposed to seeding in nurseries, seed may be scattered by helicopter or by crews walking over the area and depositing seed in selected spots. Seed used in seeding operations is normally treated with chemicals to provide protection from seed eating rodents and birds. Protection may be obtained when seed eating rodents "learn" not to eat treated seed after having ingested sublethal amounts. Protection from birds may be obtained by changing seed color.

Planting (P. 7K).

Tree planting is done by hand, using tools such as hoes, mattocks, dibbles, power augers, or tractor-drawn machines where terrain is favorable. Trees used in planting are classified as "bare-root" or "containerized." Bare-root seedlings are removed from the ground in forest nurseries, packaged and transported to the forest to be planted. Containerized seedlings, however, are grown in containers and are transported to the forest in the containers. Depending upon the specific type of container, the planter may either remove the seedling from the container prior to planting it, or plant the container itself.

Tree seedlings are commonly treated in the nursery with a chemical to repel animals that may otherwise feed upon them. Repellency may be secured by rendering the treated tree unpalatable; growth that occurs after planting is not protected. As with seeding, one or more of the following described treatments may be used in an attempt to insure that planted trees live and grow at satisfactory rates.

Chemical Weed Control (P. 7L).

Chemicals are commonly used to control undesirable vegetation. Atrazine, simazine, dicamba, or 2,4-D are applied to herbaceous vegetation. Silvex and 2,4-D are used for woody vegetation. Treatment may be accomplished prior or subsequent to seeding or planting. Applications are made by aerial or hand methods.

Baiting (P. 7M).

Poisoned bait may be distributed, aerially or by hand, to kill seed or seedling eating animals such as mice, woodrats, rabbits, snowshoe hare or porcupines.

Fencing and Screening (P. 7N).

Construction of fences or screens protect seed or seedlings from animal damage. Fencing generally involves protection of entire areas from domestic livestock or big game, while screens may be used to protect individual trees or seed spots from nearly all kinds of animals.

Mulching (P. 7O).

Usually involves placement of paper or plastic mulch around individual trees to control competing herbaceous vegetation.

Snag Felling (P. 7P).

Live or dead trees sometimes have to be felled if they are tall enough to interfere with low flying aircraft conducting herbicide applications. Dead trees (snags) are often felled to prevent their throwing sparks in the event of a fire.

Fertilization (P. 7Q).

This practice involves aerial distribution, usually by helicopter, of a fertilizer, primarily nitrogen in the form of urea prills. Application rate is generally between 150 and 300 lbs. of nitrogen per acre. Although effects of a single application of fertilizer on annual growth can usually be recorded over a 10-year period, there may be a marked reduction after approximately 5 years. Frequency of application thus ranges between 5 and 10 years depending on local conditions.

Fertilization involves the movement of tons of fertilizer from supplier's base (by rail boxcar or truck and trailer) to an intermediate point, and from the intermediate point (usually by dump truck) to the base of operation (airstrip or heliport). The operation may thus require construction or improvement of the forest road system to allow movement of large vehicles to the fertilization site. Heliports or airstrips may also have to be built.

Precommercial Thinning (P. 7R).

Surplus trees in established stands of young, premerchantable timber are cut or poisoned so as to release selected trees from competition for light, moisture or nutrients, thereby concentrating growth potential of the stand on fewer trees of better quality. The primary objectives of this practice are to produce merchantable wood volume and financial returns earlier than the unthinned forest, and to produce more total wood for harvest. Thinning of merchantable size stands, where trees removed are sold, is discussed in the section Intermediate Cuttings.

Precommercial thinning may involve the use of power saws, chemicals (silvicides such as cacodylic acid or MSMA), axes or other tools to cut or poison individual surplus trees. Surplus trees are usually chosen from those trees whose crowns make up the general level of the stand canopy. Unwanted trees taller than the general level of the stand (such as wolf trees, malformed dominants, etc.) may be cut or poisoned only if soil moisture is a critical factor for increased growth of remaining trees. Cut trees may be left standing or forced to the ground.

The above techniques may also be used to cut or poison rows, or strips, of trees on the basis of predetermined spacing or pattern with little or no regard for their position in the crown canopy. This method, termed mechanical thinning, is usually limited to very young, uniform stands. Mechanical thinning may also involve use of heavy machinery, such as crawler tractors and tractor-drawn brush cutters, to crush strips of trees several feet wide leaving narrower strips of standing trees in between.

Precommercial thinning may also be done for the primary purpose of removing diseased trees in order to control an infection such as dwarf mistletoe.

Pruning (P. 7S).

Limbs are sometimes removed from selected immature trees which are reserved for final harvest. This is done to improve timber quality by increasing the volume of clear (knot free) wood produced, or to control disease; e.g., dwarf mistletoe.

F. Protection

The primary objective of the forest protection activity is to eliminate or minimize losses to the timber resource and other forest resource values resulting from fire, insects and disease. Since the nature of these destructive agents and the practices employed in combating them vary, each will be discussed separately in the parts that follow.

Fire

Two basic approaches taken on the ground to protect the forest from fires or to control their spread involve hazard reduction and suppression. Hazard reduction includes such preventive or presuppression practices as slash (logging debris) disposal through chipping or burning, salvage of dead material, fire line construction around cutting areas, road building, firebreaks, and snag felling. Because most of these practices have several objectives and are carried out in the course of the actions identified in this statement as either Harvest or Development, they are discussed under one of those actions and not under Protection. Consequently, this section will be limited to practices employed in the suppression or control of going fires.

The objective of fire suppression practices is to break the fire triangle (fuel, oxygen and temperature) at the most vulnerable place by the means available. The application of these practices, often in combination with one another, can therefore be classified on the basis of the three sides of the triangle, as follows:

- Fuel. Reduction of fuel available for combustion by making a break in fuel continuity, accomplished by physical removal (construction of a fire line), making fuels less available (felling snags) or by making fuels fire-resistant through application of dirt, water, or chemical retardants.

- Oxygen. Reduction of oxygen available for combustion by burial of fuels in dirt, smothering with water, fog or chemical substances.

- Temperature. Reduction of temperature through application of soil, water, or chemicals and partial removal or separation of fuels.

The application of water and chemical retardants in combating forest fires is usually accomplished by means of helicopters and fixed-wing aircraft. Fire lines are constructed by hand tools and also by the use of heavy equipment such as bulldozers.

Insects

The objectives of forest insect control practices include minimizing forest injury by preventing or suppressing epidemic outbreaks of insect populations with available man-devised methods while giving every encouragement to natural control agencies toward regaining the natural ecological balance.

Control practices can be classified as silvicultural, biological, chemical and physical; the choice of which is primarily dependent upon the species of insect to be controlled, the degree of infestation, and the conditions that characterize the infested area.

Silvicultural Control (P. 8A). This method employs the use of silvicultural practices directed towards preventing the occurrence of insect outbreaks as opposed to actions taken following insect infestations. These practices maintain the forest in a healthy condition and regulate its growth so that food conditions are unfavorable for injurious insects. The quantity and quality of insect food are controlled by regulating the composition, density, vigor and age of the stands. Practices include the salvage or burning of windfalls, slash, and other potential insect-breeding places, and harvesting of the trees or stands most susceptible to insect attack. Under certain conditions cutting and regeneration practices are employed in a manner which will favor the creation of timber stands of mixed species, since they are sometimes less susceptible to insect damage than pure stands. The objectives and practices associated with silvicultural control are an integral part of the timber management program.

Biological Control (P. 8B). This method involves the use of living organisms which are either collected in an area where they are abundant or propagated under confinement and then released in the infested area. These organisms can be classified as:

- Parasites -- usually the young life forms of certain wasp and fly families.

- Predators -- such as lacewing flies, certain beetles, birds and mammals.

- Virus diseases -- produced by many different micro-organisms, including bacteria and fungi.

While biological control methods have had some spectacular results with agricultural crop pests, their application in combating forest pests has not been highly successful.

Chemical Control (P. 8C). This method involves the use of chemicals which kill the insect by suffocation or through entry via the body wall, digestive tract or respiratory system. Insecticides are classified as:

- Inorganic -- Arsenic, fluorine, mercury, copper, or zinc.

- Botanical -- Rotenone, nicotine and pyrethrum.

- Synthetic Organic -- Chlorinated hydrocarbons such as methoxychlor.

- Mineral Organic -- Kerosene, fuel oil and lubricating oil which along with water are often also used as carriers for the other insecticides.

Insecticides are applied to trees in a number of ways, the choice being dependent upon the insect involved, the insecticide used and its formulation and the equipment available. The most common method, particularly in combating defoliating insects, is spraying or dusting from an aircraft since it can be applied rapidly to large forested areas inaccessible from the ground. Ground methods include hydraulic spraying equipment mounted on vehicles and hand-operated units, used when total coverage of the tree or log is necessary. Mist blowers, employing engine-powered fans, can also be utilized as mobile ground units to disseminate insecticides. Another method, used primarily for bark beetles, involves the injection of chemicals into the sapstream of a tree. These chemicals are then taken up through the trunk, killing the beetles in the inner bark.

Direct Physical Control (P. 8D). Mechanical and physical insect control methods, usually aimed at beetle-type insects, include the use of the following methods:

- Burning -- involves the burning of infested unmarketable material in tree, log, branch (following pruning) or bark (following peeling) form after the material is piled or decked. Standing trees may also be burned.

- Solar Radiation -- involves turning thin-barked trees or logs so as to fully expose each beetle infested side to full sunlight for several days.

- Logging -- involves the removal of marketable material to utilization centers and burning of the residual infested material. With the exception of widespread infestations, this method is usually carried out in the course of the "normal" timber management program.

- Trapping -- involves the use of light, chemical attractants, and girdled and/or felled trees to attract insects. In the latter case the material is destroyed usually by burning.

Diseases

The objective of forest disease control practices is to eliminate or minimize the occurrence or spread of heart rot, root rot, rusts, foliage infections and other tree diseases. Diseases may be caused by the non-living environment, such as unfavorable soil or atmospheric conditions, or by viruses whose nature is not yet understood. The majority of diseases, however, are caused by the activities of living organisms, i.e., slime, molds, bacteria, fungi, algae, seed plants and animals, including insects.

Disease control measures currently carried out in the forest are essentially limited to silvicultural or physical practices. While a chemical has been developed for treating stumps to prevent the spread of Fomes annosus (root and butt rot fungus), the small amount of damage caused by this disease does not warrant its application. Chemicals are used, however, in nurseries and seed orchards for disease control and are discussed under the Forest Development phase of the timber management program. Biological control, like chemical control, has strong appeal to the imagination but current technology and/or experience offers little hope for application in the forest in the foreseeable future. Consequently, biological control measures are not described in this statement.

Silvicultural Control (P. 9A). This method employs the use of silvicultural practices aimed at the prevention or minimization of future disease outbreaks as opposed to actions taken following infestations. Silvicultural control measures include:

- Development of disease-resistant trees such as rust resistant white pine and sugar pine.

- Development of mixed-species stands where feasible, particularly when diseases are host specific.

- Development of pure stands of naturally disease-resistant tree species where feasible.

- Avoiding damage to residual trees during logging operations.

- Maintaining stands in healthy and vigorous condition by regulating composition, density and age.

Direct Physical Control (P. 9B). This method employs the use of physical or mechanical means to control existing disease infestations and to recover marketable material, when applicable. Direct control practices currently being used are almost completely limited to dwarf mistletoe control and are usually carried out by use of silvicultural practices. Dependent upon the degree of infestation, stand composition, tree size and other variables, either of the two following general approaches may be taken:

- Complete removal of all trees on and immediately adjacent to the infested area by cutting, burning or poisoning. Marketable material to be utilized.

- Removal and/or pruning of infected trees through precommercial thinning, commercial thinning or other partial cutting operations. Consists largely of discriminating against infected trees or disease prone species in selecting trees to be cut in the course of standard silvicultural practices.

II. DESCRIPTION OF EXISTING ENVIRONMENT

There are three major biomes found in western Oregon; namely the Coniferous Forest, Grassland, and Woodland-Bushland. To delineate more precisely the ecological variations within the three broad biomes, further breakdown into sub-biomes is made. The Coniferous Forest Biome in western Oregon includes the Northwest Coastal Coniferous Forest sub-biome and the Montane Forest sub-biome. The Grassland Biome is represented in southwestern Oregon by the Palouse Prairie Grassland sub-biome. The Woodland-Bushland Biome is represented by the Broad Sclerophyll sub-biome.

Although precise boundaries between biomes and sub-biomes are not distinguishable in the field, they are employed in this statement in order to utilize the basic advantages of the biome approach. Upon this basis, then, data on the existing environment are collected.

Brief geographic descriptions of the sub-biomes are as follows (see Figure 5):

- Northwest Coastal Coniferous Forest (Sub-biome 1). This forest extends from the northern to the southern border of western Oregon. The crest of the Cascade Mountains marks the eastern reach of the Coastal Forest, and the Pacific Ocean bounds the western reach. At approximately 43° N latitude, the Coastal Forest constricts to a narrow band along the west slope of the southern Oregon Siskiyou and Coast Range Mountains.

- Montane Coniferous Forest (Sub-biome 2). That portion of the Montane Forest considered herein is located in southwestern Oregon, generally ranging south from 43° N latitude to the California border, and extending west from the line between Ranges 8 and 9 East to the summit of the Coast Range.

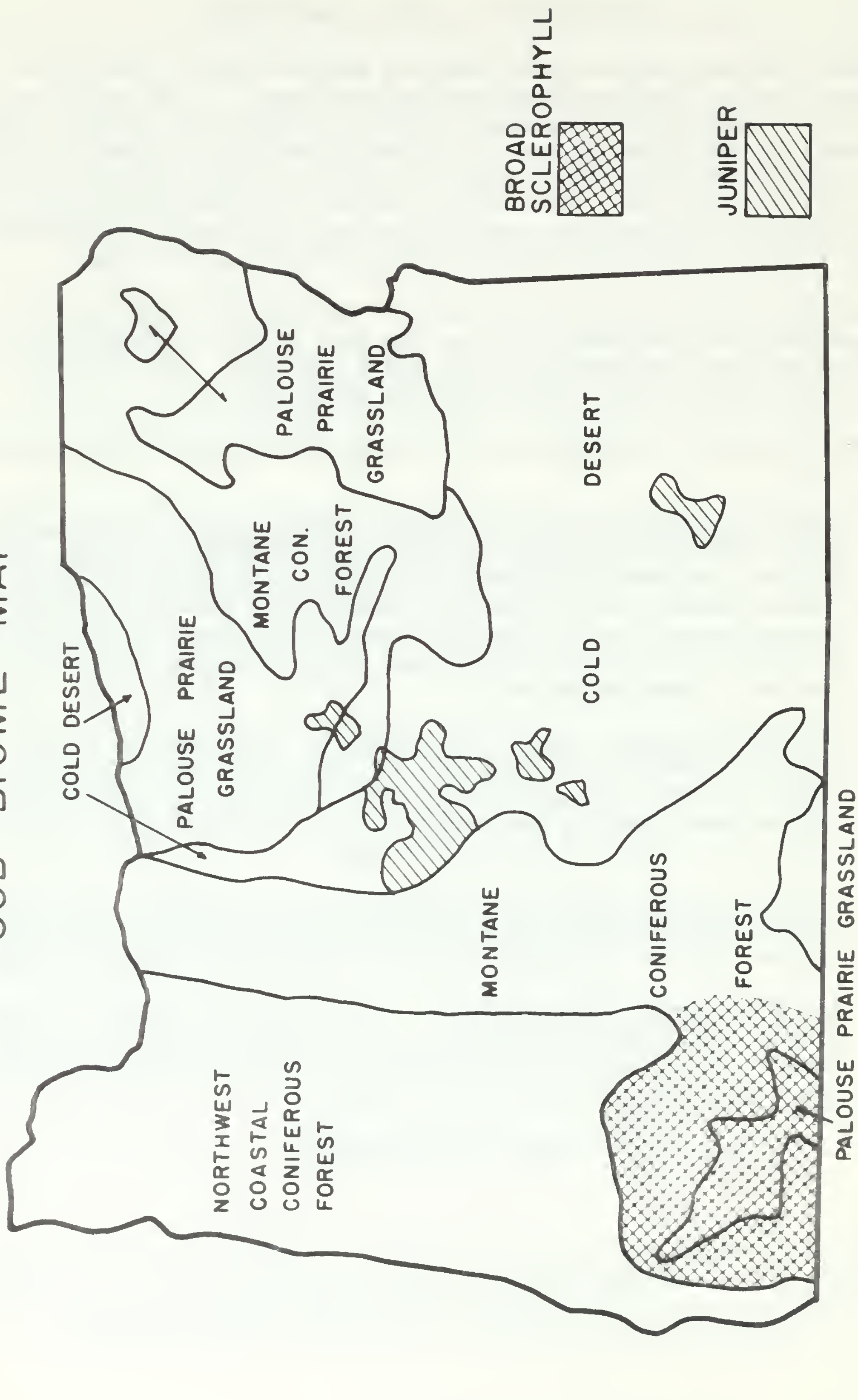
- Palouse Prairie Grassland (Sub-biome 3). The portion of the sub-biome of concern here is an extension of the northern California Palouse Prairie extending into the southwestern corner of Oregon.

- Broad Sclerophyll (Sub-biome 4). The Broad Sclerophyll sub-biome occurs as biological islands within the southwestern part of the Montane Forest and that portion of the Palouse Prairie Grassland which is located in southwestern Oregon.

A. Non-living Components

Air

The State of Oregon lies mostly between latitudes 42° and 46° North, and extends inland from the Pacific Ocean for some 375 miles. Its area of about 96,700 square miles includes more than 1000 square miles of water surface. Bordering the Pacific, the Coast Range extends from north



SUB - BIOME MAP

to south. Its crest is generally at elevations between 1500 and 2000 feet. Further to the east, the Cascade Range also lies on a north-south axis, with a summit ridge mostly between 5000 and 6000 feet above sea level. Through these mountain ranges, the Columbia River gorge forms a relatively narrow, nearly sea level passage between the Pacific and the intermountain plateau.

This combination of oceanic and continental atmospheric influences with varied topography and land forms gives western Oregon a wide range of regional and local climates. Westerly winds from the Pacific predominate; they move large masses of marine air eastward, modifying the climates of the western parts of the state. The coldest weather in winter and the warmest days of summer occur when these ocean winds cease and the state is blanketed by a mass of continental air.

High pressure systems in late summer and early fall commonly cause extended periods when portions of western Oregon are covered by a stagnant air mass. The worst manifestation of this condition occurs in the Eugene-Springfield area of the Willamette Valley.

East winds occasionally cause very low humidity in western areas of the state. This sometimes occurs even in the winter season. Generally, humidity is high west of the Cascades in winter, and on the coast throughout the year.

The general eastward movement of marine air masses keeps temperatures moderate most of the time. Infrequently, continental high pressure areas reverse the flow, sending westward dry air that is hot in summer and cold in winter.

The very cold arctic air that forms over Canada in winter is usually barred from the Columbia Basin by the Continental Divide. Occasionally, however, arctic air masses cross the Divide and move southward between the Rocky Mountains and the Cascades. This very cold, dry air then spreads out over the Columbia Basin and the intermountain plateau, causing the more extreme winter temperatures. The Columbia River gorge allows continental air to flow into western Oregon from east of the Cascades to a greater extent than it otherwise would. This is particularly true of cold air in winter.

During the winter months, coastal southerly and southwesterly winds originating in Pacific low-pressure systems may become very strong, occasionally developing hurricane force. These winds move inland a few times each winter and are sometimes destructive.

Thunderstorms are rare in the western valleys but are common in the Cascades where many forest fires are caused by lightning.

Land

Physiography and Geology. Western Oregon lies within two major physiographic provinces, Pacific Border Province and the Cascade Sierra Province. These major divisions are further classified into sections, the sections being the smallest recognizable unit. A physiographic classification is based on those geologic processes acting on different rock types and rock structures which erode at different rates to form regions separated by recognizable boundaries. The following table is a classification of the physiographic units in western Oregon. These are shown on the physiographic map on the next page, (Figure 6).

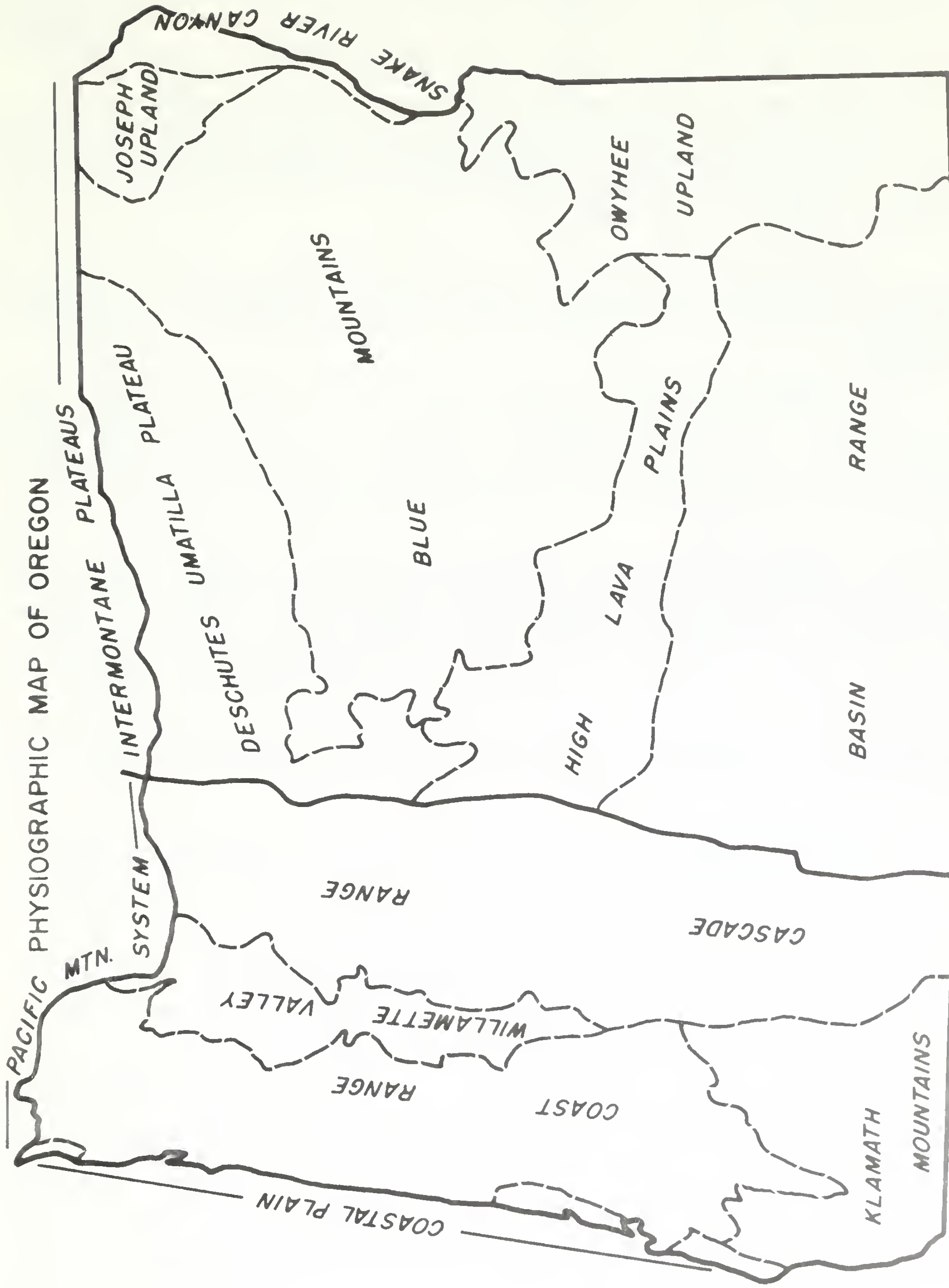
Division	Province	Section
Pacific Mtn. System	Pacific Border Province	Oregon Coast Range Klamath Mountains Willamette Valley
	Cascade Sierra Mountains	Western & High Cascade Mtns.

The Oregon Coast Range section, a dissected arch of marine sediments, lies between the Klamath Mountains on the south and the Columbia River on the north. It is distinguished from the Klamath Mountains by being made up of younger and less resistant rocks. The foot of the range is generally well marked as it descends on the east to the Willamette Valley. South of latitude 44° it borders the Cascade Range. Between Eugene and Roseburg the range is made up of a belt of rough hills, 10 to 20 miles long, rising 500 to 1000 feet above the valleys. To the west, Tyee Mountain rises to a height of 2600 feet or about 1000 feet higher than the surrounding hills.

To the south the hills rise 3000 feet to 5000 feet in elevation. The main streams flow toward the west. A coastal plain up to 3 miles wide borders much of the range and varies in elevation from 50 feet to 250 feet.

The marine sedimentary rocks in this section are all tertiary in age and generally weak in nature. Volcanics are contemporaneous with or intruded into the sediments and are more resistant, forming nearly all capes and promontories on the coast and most high peaks. Structurally the range is a low anticlinorium.

The Klamath Mountains lie west of the Cascade Range between the Coast Range of Oregon and California. The mountains in this section are older and more complex than the adjacent ranges. The drainage system is transverse and shows little order as the streams have adjusted to a complex geologic structure.



PHYSIOGRAPHIC MAP OF OREGON

The southern part of the range is higher in altitude than the adjacent California Coast Range. Generally, the altitude near the coast is 2000 feet to 2500 feet, and rises inland to a maximum height of approximately 7000 feet. The Rogue River crosses the range at about latitude 42°30', and the Klamath River flows west a little south of the 42nd parallel. The streams have cut narrow canyons 1000 feet to 2000 feet deep where the rocks are strong and form narrow bottomlands where the rocks are weak. Marine terraces and eroded sea cliffs, some as high as 1500 feet are found along the western margin of this section.

The Klamath Mountains section lies mostly within the Montane Coniferous Forest with the western and northern portions extending into the Northwest Coniferous Forest. These mountains also contain a portion of the Broad Sclerophyll.

Most of the rocks in this section are Mesozoic in age and have been metamorphosed, including many masses of ancient volcanics and sedimentaries. Granitics are also present. Thus the rocks are fairly strong and resistant. The rocks have been folded and faulted with the general trend toward the northeast and southwest.

The Willamette Valley in Oregon is similar to the Puget Trough to the north but is unglaciated. The altitude of the floor is about 500 feet. The topography varies from a flat alluvial plain, which makes up about two-thirds of the district, to low hills. The stream pattern is braided and becomes quite sluggish in the Eugene area, and floods are common.

Rocks within the section are mostly glacial and alluvial sediments overlying older sediments. The low hills are composed of basalts or less resistant sedimentary rocks.

The Cascade Range is divisible into the Western Cascades and High Cascades; it is best described as a great pile of volcanic rocks. The older Western Cascades are maturely dissected. Rocks range in age from Eocene to possibly early Pliocene. Eocene to lower Miocene rocks are chiefly pyroclastics with interbedded lava flows and lenses of waterlaid sediments. Middle Miocene Rocks are predominantly basaltic lavas which cap higher ridges and may be remnants of shield-type volcanoes. Younger rocks vary from pyroclastics to basalts.

The High Cascades are the majestic volcanic peaks, cinder cones, and relatively undissected lavas on the east side of the Range. Original constructional form of most central vent volcanoes has been severely modified by glaciation. Most peaks are Plio-Pleistocene in age; recent flows and cinder cones are common. Lavas are dominantly basaltic andesites and olivine basalts. Some rhyolite and obsidian flows are present. Pumice blankets large areas. Intracanyon basalts of Pliocene age extend into the Western Cascades from the High Cascades. The highest peak is Mount

Hood, 11,235 feet. The Cascade Range is covered by the Coniferous Forest Sub-biomes, and in the southern portion, supports a segment of the Broad Sclerophyll.

Soils. The system of soil classification in the U.S. is similar to the systems used to classify plants and animals. Soil classification utilizes the soils' physical, chemical and mineralogical properties as well as factors which influence plant growth. Climate, soil depth, coarse fragment content and soil drainage are a few of the items which influence plant growth and are used to separate one kind of soil from another.

There is a tremendous variation in kinds of soils occurring in western Oregon. This variation decreases as one ascends the categorical rungs of the classification scheme. Each sub-biome contains a group of soils, at some higher level of classification, which are similar in many characteristics. This is because climate and vegetation are reflected in soil development just as climate and soils are major items in the evolution of a plant community.

On the above premise some of the major soil series will be discussed for each sub-biome. It must also be remembered that the soils in each sub-biome are quite variable when considered at the lower classification categories (the more detailed separations). There are transitional types of soils which occur in more than one sub-biome. The major soils discussed for each biome occur extensively and are examples of numerous soil series with similar characteristics.

Soils discussed will be identified in one of two ways. Soil series officially established by the Soil Conservation Service will be identified by name. Soil series not officially established will be identified by numerals.

General definitions of terms used in the following sections are as follows:

Soil Texture

Clayey - Soils containing over 35% clay in the fine earth fraction.

Clayey-skeletal - Soils containing over 35% coarse fragments by volume and more than 35% clay in the fine earth fraction.

Loamy-skeletal - Soils containing greater than 35% coarse fragments by volume and the fine earth fraction contains less than 35% clay.

Fine-loamy - A soil containing 15% or more particles which are greater than 0.1 MM in size and contains 18 to 35% clay in the fine earth fraction.

Coarse-loamy - A soil containing 15% or more particles which are greater than 0.1 MM in size and contains less than 18% clay in the fine earth fraction.

Climate.

Temperature - Mesic soils have mean annual temperatures of 47° F. or more. Frigid soils have mean annual temperatures less than 47° F.

Moisture - Xeric soils are dry for 60 consecutive days, 7 out of 10 years. Udic soils are not dry for 90 cumulative days nor 60 consecutive days.

Northwest Coastal Coniferous Forest (Sub-biome 1). Thomas, Pomerening and Simonsen listed the soils which occur in the uplands adjacent to the Willamette Valley.

The Jory series is a red, clayey soil occurring in xeric-mesic zone at lower elevations adjacent to the interior valleys. Honeygrove soils are similar to the Jory soils except they occur at intermediate elevations in the udic-mesic zone. Both soils are located in the Cascade and Coast Range Mountains. The Kinney soils are brown, fine-loamy and Hembre soils are red, fine-loamy. Kinney and Hembre soils also occur in the udic-mesic zone. Kinney soils are located at intermediate elevations in the Cascade Mountains. Hembre soils are located at intermediate elevations in the Cascade and Coast Range Mountains. Astoria soils are brown, fine soils occurring in the udic-mesic zone. These soils are dominantly located on the west side of the Coast Range Mountains and areas in the north which drain into the Columbia River.

Digger and 564 soils are brown, loamy-skeletal and are located on sedimentary bedrock in the Coast Range Mountains. 564 soils are less than 20 inches to hard bedrock. Both of these soils occur in the udic-mesic zone.

Bureau of Land Management has mapped extensive acreages of 381 and 371 soils in the xeric-mesic zone of the Klamath Mountains. The 381 soils are red, clayey-skeletal while the 371 soils are brown and loamy-skeletal. Orford soils are located on the southern Oregon coastal areas. These soils are brown, clayey and occur in the udic-mesic zone. The brown, coarse-loamy Siskiyou soils occur in the Siskiyou Mountains and are in the xeric-mesic climatic zone.

Some soil properties and interpretations for these soils listed for the above biome are listed in Table 1. Detailed soil reports must be referred to for specific ratings under various conditions for these soils and for other soil series not listed above.

Table 1 - Engineering Classifications, Hazard Ratings, and Relative Productivity for Selected Soil Series

Soil Series	Unified Class (subsoil)	Hydro Group	Landslide Hazard 35-60% slopes	Landslide Hazard 60% + slopes	Erosion Hazard[1/] 35-60%	Erosion Hazard[1/] 60% + slopes	Compaction[2/] Hazard	Productivity[3/] D. fir Site Class
Jory	CL	C	mod-stable	unstable	med	high	high	III
Honeygrove	MH	C	mod-stable	unstable	med	high	high	II
Kinney	SM	B	mod-stable	mod-stable	med	high	medium	II
Hembre	ML	B	stable	mod-stable	med	high	medium	II
Astoria	MH	B	unstable	unstable	high	very high	high	I
Digger	SM	C	unstable	unstable	med	high	medium	IV
564	GM	D	unstable	unstable	med	high	low	V
381	ML	C	mod-stable	unstable	med	high	high	IV
371	SM	B	stable	mod-stable	med	high	low	IV
Orford	MH	C	mod-stable	mod-stable	med	high	high	II & III

1/ Based on bare soil surface

2/ Based on reduction of pore space which impedes root development and air and water movement

3/ USDA 1949 Technical Bulletin No. 201

Broad Sclerophyll and portions of the Palouse Prairie (Sub-biome 4). Power and Simonsen describe the soils occurring in the Broad Sclerophyll sub-biome. Carney soils are xeric, mesic, well drained, dark brown, clay and occur on footslopes. Freezener soils are xeric, mesic, deep, well drained, reddish brown, clays. They are formed over basalt and occur in the steep uplands. Josephine soils are xeric, mesic, moderately deep, well drained, reddish brown clay loams. They are formed over metamorphased sandstone and shale and occur in the uplands. Pearsoll soils are shallow, xeric, mesic, reddish brown clays. They are formed over serpentine bedrock and occur in the foothills and uplands. These soils are unique as they contain sufficient magnesium to inhibit many plant species. Siskiyou soils are xeric, mesic, moderately deep, excessively drained, yellowish brown sandy loams. They are formed on granitoid rocks and occur in the foothills and uplands. Medford soils are xeric, mesic, deep well drained, black silt loams. They are formed in alluvium and occur on terraces and valley bottoms.

Table 2 lists some characteristics of the above soils.

Table 2 - Engineering Classification, Hazard Ratings and Relative Productivity for Selected Soils

Soil Series	Unified Classification (subsoil)	Hydrologic Group	Compaction 1/ Hazard	Erosion 2/ Hazard	Productivity
Carney	CH	D	high	med-high	--
Freezener	MH	B	med	high	--
Josephine	MH	C	high	high	SI=140 (D. fir)
Medford	CL or ML	B	med	low	6-7 T of hay/A
Pearsall	CH	D	high	high	--
Siskiyou	SM	B	low	high	SI=110 (sugar pine)

1/ Based on reduction in pore space which impedes root development and air and water movement

2/ Based on a bare soil surface

Water

The characteristics of the water resource vary markedly across Oregon, and the boundaries for areas with similar characteristics will differ from those of the biomes and sub-biomes and of the physiographic and geologic areas described in the previous section. The subdivisions of Oregon used in this section for describing the water resource were adapted from the Columbia-North Pacific Region Comprehensive Framework Study, Appendix V, and are shown in Figure 7. The description of the water resource within each of these subdivisions will include the characteristics of the surface water, the ground water, the chemical quality and the sediment load of these waters.

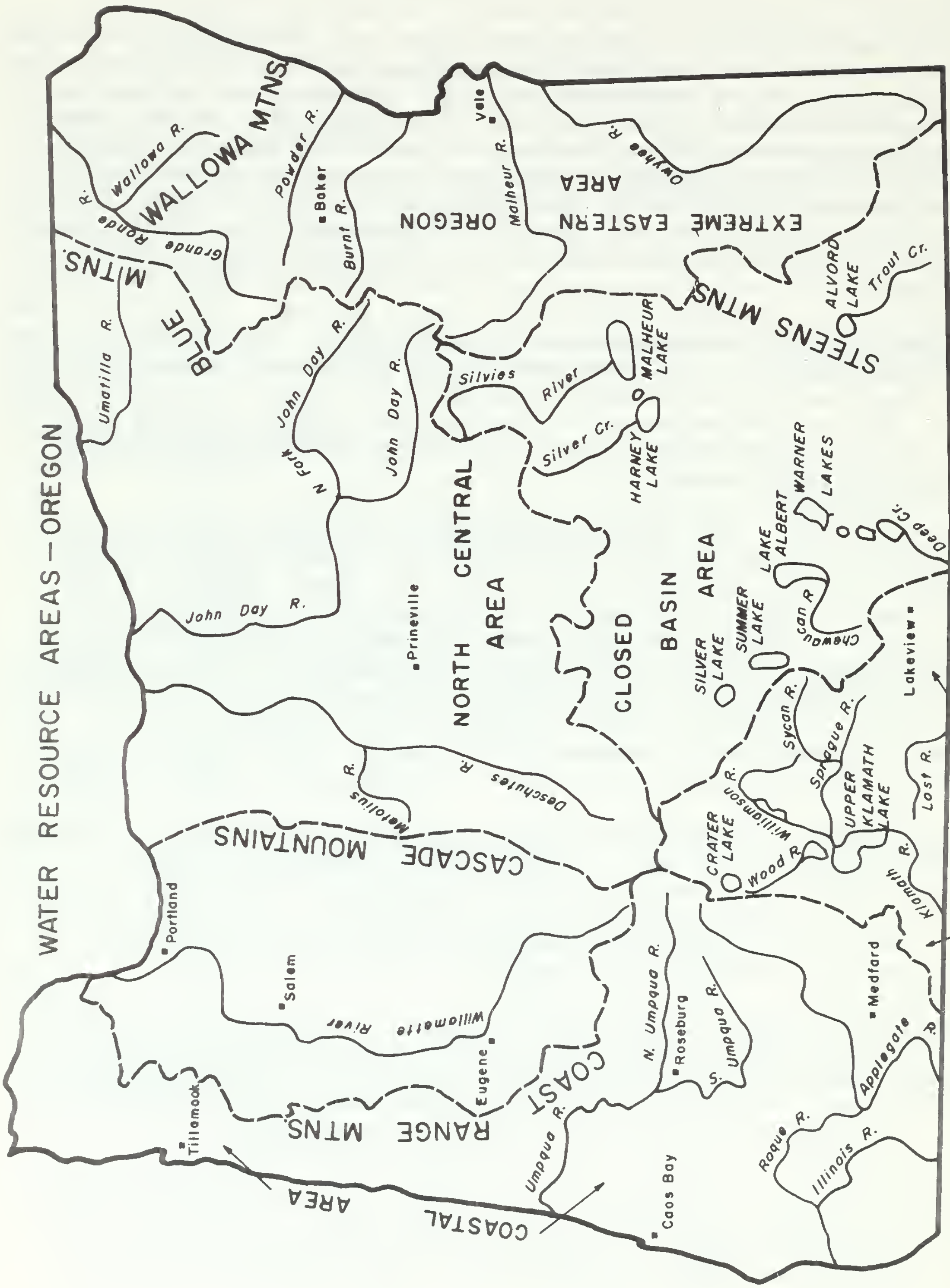
Coastal Area. This subdivision includes all the small coastal rivers west of the Coast Range in the northern part, and those large coastal rivers which head in the Cascade Mountains in the southern portion of the State. The northern portion is included in the Northwest Coastal Coniferous Forest and the southeastern portion is included in the Broad Sclerophyll and Palouse Prairie Grassland.

—Surface Water. The coastal streams in the northern portion of this subdivision yield the greatest amount of annual runoff--about 100 inches for both the Wilson and the Siletz Rivers. The runoff decreases southward to about 35 inches per year for the Umpqua and the Coquille River basins and 30 inches for the Rogue Basin. Winter rainfall is the major source of runoff, particularly in the northern portion, with a secondary source from snowmelt in the Upper Umpqua and Rogue Basins. Those streams with rainfall as the main source of runoff have a seasonal peak from December to January and a seasonal low in August. Those streams whose runoff is supplemented by snowmelt have a secondary peak in May and June.

The quality of the surface waters is generally very good; the streams are very dilute and very soft. In the northern portion, the total dissolved solids range from about 30 to 50 mg/l, with the range in hardness from 8 to 30 mg/l with calcium and bicarbonate as the major ions. Some of the lower tributaries of the Rogue River contain water with a higher portion of magnesium bicarbonate.

Suspended sediment yield from the coastal area is generally low. About 89 percent of the area yields 0.1 to 0.2 acre feet per square mile per year. Portions of the Upper Rogue yield 0.02 to 0.1 AF/SMY and areas around the Upper South Fork of the Umpqua, the South Fork of the Coquille River, and the Upper Wilson River yield 0.2 to 0.5 AF/SMY.

—Ground Water. Most of the area is classified as yielding 1 to 20 gallons per minute of water to a well. An exception is the southwestern portion of the west slope of the Cascade Mountains whose ground water yield is unknown but which is underlain by volcanic material capable of yielding moderate to large supplies in the higher elevations and small


WATER RESOURCE AREAS — OREGON
COASTAL AREA
NORTH CENTRAL AREA
CLOSED BASIN AREA
KLAMATH AREA
EXTREME EASTERN OREGON AREA
CASCADE MOUNTAINS
COAST RANGE MTNS
BLUE MTNS.
WALLOWA MTNS
STEENS MTNS
Portland
Salem
Eugene
Tillamook
Coos Bay
Roseburg
Medford
Lakeview
Prineville
Baker
Vale
Willamette River
Deschutes R.
Metolius R.
John Day R.
N Fork John Day R.
Umatilla R.
Grande Ronde R.
Wallowa R.
Powder R.
Burnt R.
Malheur R.
Owyhee R.
Silvies River
Silver Cr.
Trout Cr.
Deep Cr.
Chewaucan R.
Sycan R.
Sprague R.
Williamson R.
Wood R.
Lost R.
Klamath R.
Umpqua R.
N. Umpqua R.
S. Umpqua R.
Rogue R.
Applegate R.
Illinois R.
MALHEUR LAKE
HARNEY LAKE
ALVORD LAKE
WARNER LAKES
LAKE ALBERT
SUMMER LAKE
SILVER LAKE
CRATER LAKE
UPPER KLAMATH LAKE

to moderate supplies in the lower elevations. The best aquifers are the alluvial deposits along the major streams and beach deposits. These sites may yield from 20 to 500 gallons per minute.

Ground water recharge is almost entirely by direct rainfall on the areas of outcrop of the aquifer. About 80 percent of the area is underlain by geologic material whose specific yields (the percent by volume of the material which is capable of yielding water to a well) are estimated to be 2 percent or less. This characteristic determines the relationship between surface water and ground water as described below:

> "With the combination of low specific yield and heavy rainfall, the water table rises rapidly and comes quickly to a level where ground water discharges into even the most minor of drainage channels in the rugged terrain. Generally, the water level reaches a peak in early winter or midwinter; thereafter, continued heavy precipitation merely maintains the water level at relatively high levels. During periods of a week or two without rainfall, the water table declines sharply."

Ground water generally has a dissolved solids concentration of from very low levels up to 500 mg/l. Commonly, more highly mineralized water is encountered at depths of several hundred feet. A few wells have encountered saline water at depths of less than 100 feet. Iron and hydrogen sulfide are problems in some supplies. Boron concentrations of 1 to 20 mg/l are found in the Medford area along with excessive fluoride.

Willamette Area. This area includes the Willamette River and its tributaries and extends from the crest of the Coast Range east to the crest of the Cascades and from the Columbia River south for 150 miles. This area is included in the Northwest Coastal Coniferous Forest.

Surface Water. Streams which enter the Willamette River from the Coast Range (west side of the valley) have a distinctly different hydrograph shape than the streams from the Cascade Mountains (east side of the valley). The west side streams have one main peak flow period per year, from December through January, as a result of heavy winter rains with relatively little snow. Rainfall on the crest of the Coast Range averages from 100 to 200 inches per year in the northern part, and decreases to 60 to 90 inches per year in the southern portion. On the east side of the valley, winter snowpack may form a significant part of the yearly runoff and this causes a second peak in the hydrograph from these streams in April and May. Runoff from the entire basin averages about 43 inches per year.

The quality of surface water in the Willamette area is generally good with the dissolved solids content ranging from 38 mg/l to about 95 mg/l. The surface waters contain ions of the calcium magnesium bicarbonate type.

Of particular significance is the lack of an increase in the salt load from irrigation return flows since the earliest chemical analyses in 1910. This low salt load (about 0.02 ton/acre/year) is due in part to the humid zone and the well leached soils that contain only small quantities of soluble salts. The total dissolved solids load for the Willamette basin is estimated to be about 0.28 ton/acre/year.

About 80 percent of the annual sediment discharge occurs during the high rainfall and high runoff period from November to February. About 90 percent of the area yields from 0.1 to 0.2 acre-feet/square mile per year. Suspended sediment concentrations for large streams range from less than 100 mg/l to about 400 mg/l, but may exceed 2000 mg/l during major floods.

—Ground Water. Perhaps 65 percent of the Willamette area is underlain by geologic material which yields 1 to 20 gallons per minute to wells. Yield from the volcanic rocks of the Cascade Mountains is generally unknown, however, the character of streamflow in this region indicates yield to wells may be moderate to large. The best aquifers are found in the alluvial deposits of the Willamette River and its major tributaries. This material will yield 20 to 500 gallons per minute.

Ground water quality is generally good with low fluoride and boron concentrations and low sodium absorption ratio. Iron concentrations may be in excess of recommended limits in some wells. Most ground water has dissolved solids concentrations of less than 500 mg/l. Water from marine strats may be moderately to highly saline at depth of a few hundred feet. In a few places, saline water may be encountered at less than 100 feet.

B. Living Components

Aquatic Vegetation

Vegetation is a vital component of aquatic ecosystems because plants are the beginning of the food chain--only they can fix biochemical energy and synthesize basic organic substances. Aquatic plants therefore provide food and cover for insects, other invertebrates, fish, waterfowl, fur bearers, big game, and non-game birds and animals. Growth of aquatic vegetation along streambanks and lakeshores prevents soil erosion and contributes to the natural beauty of the ecosystem.

Some aquatic plants grow in nearly all waters of the state depending on suitable temperature, water depth and movement, available nutrients, salinity, light for photosynthesis, and sufficient time for growth and reproduction. The aquatic environment is often classified as either running (lotic) or standing (lentic) water habitat.

The running water habitat includes the smallest mountain streams at high altitudes to major rivers at low elevations. Water originating in all watersheds in western Oregon eventually enters the Pacific Ocean.

Streams at higher elevations generally contain less vegetation than those at lower elevations due to steeper gradients, cooler water, and a lower concentration of nutrients.

Lakes, reservoirs, ponds, marshes and bogs make up the standing water habitat of western Oregon. A greater variety and more abundant growths of vegetation usually occur in standing rather than in running water environments. Natural lakes can be classified into three groups according to their morphometry and productivity--young, maturing or old.

Most young lakes are found at higher elevations in the Coniferous Forest Biome, whereas maturing lakes occur in all biomes at all elevations. Mature lakes, ponds and marshes (both marine and freshwater, including estuaries) are areas of enormous biological productivity because of the rich waters and abundant communities of aquatic vegetation.

Aquatic plants are usually grouped into three general categories--floating, submersed and emersed. Representative plant species widespread in Oregon and probably common to all sub-biomes are listed by genera as follows:

- Floating. Green and blue-green algae; duckweed (Lemna and Spirodela); water shield (Brasenia); pond lily (Nuphar); and floating pondweed (Potamogeton).

- Submersed. Stonewort (Chara); bladderwort (Utricularia); some pondweed (Potamogeton); Hornwort (Ceratophyllum); water milfoil (Myriophyllum); water buttercup (Ranunculus); mare's trail (Hippuris); and elodea (Elodea).

- Emersed. Cat-tail (Typha); bulrush (Scirpus); yellow cress (Rorippa); buttercup (Ranunculus); bur-reed (Sparganium); water persicaria (Polygonum); water plantain (Alisma); arrowhead (Saggittaria); sedge (Carex); spikerush (Eleocharis); horsetail (Equisetum); cyperus (Cyperus); rush (Juncus); mannagrass (Glyceria); common reed (Phragmites); slough grass (Beckmannia); reed canarygrass (Phalaris); willow (Salix); alder (Alnus) and cottonwood (Populus).

Aquatic plants tend to grow in communities according to water depth, which is probably the major habitat requirement for most species. In aquatic ecosystems some plants occur in open water, others occupy the littoral zone, and different species grow along the shores of lakes and banks of rivers (riparian vegetation).

Plant communities in standing water environments are constantly changing due to natural processes. Shoal areas, for example, are developed by sedimentation from shore erosion and tributary streams. Rooted vegetation grows on the shoals and contributes to filling of lakes by retaining debris and sediment. Tributary streams continue to add more nutrients. Dense growth of emergent plants extend outward from shore. Dead plant

material accumulates and further fills the lake. Succession of grasses and sedges then converts the lake into marshes or bogs, and finally dry land. Plant succession is therefore an important factor in the gradual conversion of water bodies to land, which is a long term process requiring hundreds of years to complete under natural conditions.

Terrestrial Vegetation

Generally speaking, western Oregon is dominated by coniferous forest interrupted by the Willamette, Umpqua and Rogue River Valleys.

The following description deals only with major non-agricultural vegetative conditions such as forest zones, wherein a single tree species is the major climax dominant. Each forest zone or vegetative type described has within its boundary other kinds of undescribed (in this statement) vegetation limited to a very small proportion of the total land area. Oak (Quercus) - grass types scattered throughout the coniferous forest is one example. Another is riparian, or streamside, vegetation which forms a network throughout all sub-biomes. Riparian vegetation varies considerably and may include red alder (Alnus rubra), black cottonwood (Populus trichocarpa), and where annual flooding occurs, willow (Salix spp.). Where streams are normally confined to their banks such vegetation is more typical of the forest zone, or other vegetative type, within which it lies.

Palouse Prairie Grassland. In western Oregon this sub-biome exists in portions of Jackson, Josephine and Douglas counties. (Refer to Figure 5.)

Predominant vegetation consists of a large selection of grass species occurring in both a natural state and in extensive areas under cultivation. Sagebrush and other shrub species are interspersed with the grasslands throughout much of the area.

Growth occurs mainly during the early spring months and the grasses mature and dry by the first of July. A long frost period during the winter and a dry summer period force vegetation to remain dormant the greater part of the year. Fall growth occurs only in unusually favorable years.

Clearly the most important native grasses of the Palouse Prairie are the bluebunch wheatgrass (Agrophyron spicatum) and its close relative Agropyron inerme. Idaho fescue (Festuca idahoensis), needlegrass (Stipa comata), Sandberg bluegrass (Poa secunda), Junegrass (Koeleria cristata), and big bluegrass (Poa ampla) are the associated grasses. Bottomlands and clay soils are often dominated by giant ryegrass (Elymus cinereus) and western wheatgrass (Agropyron smithii). Sandy soils and rocky soils may support Indian ricegrass (Oryzopsis hymenoides), needlegrass (Stipa comata), and sand dropseed (Sporobolus cryptandrus). In southwestern Oregon, following fire or heavy grazing, medusahead wildrye (Elymus caput-medusae)

is the principal invader and now occupies approximately 70-80 percent of the area. As a result, bunch wheatgrass can be found only in isolated undisturbed areas.

Interspersed with the grasses are various tree and shrub species, including Oregon ash (Fraxinus latifolia), various oaks (Quercus spp.), sweetbriar rose (Rosa eglanteria) and poison oak (Rhus diversiloba). Transitional sites support larger numbers of the trees and shrubs typical of the Broad Sclerophyll sub-biome described below.

Only in the more moist borderlands are broad leaved herbs important. Balsamroot (Balsamorhiza spp.), lupine (Lupinus spp.), yarrow (Achillea spp.), mule-ear dock (Wyethia spp.), and little sunflower (Helianthella spp.) are locally abundant.

Successional changes are most often associated with grazing, fire, cultivation and other disturbances. Grazing most seriously affects the larger perennial grasses since they are preferred by cattle and sheep. Heavy grazing therefore tends to eliminate Agropyron spicatum, Festucca idahoensis, etc., and to increase sagebrush and annual grasses, particularly medusahead-rye.

Broad Sclerophyll. This sub-biome exists as scattered or interrupted areas in southwestern Oregon (see Figure 5) where sclerophyllus species (species with broad, evergreen leaves) predominate in a climax association; i.e., the final stage of plant succession. Such climax communities normally occur on the dryer (xeric) sites typical of the Umpqua or Rogue River Valley and shallow soils on southerly exposures at higher elevations or areas of high rainfall.

Vegetation common to the sub-biome may include the following broadleaf evergreen trees and shrubs (typical sclerophyllus) and deciduous species to a lesser degree:

Evergreen (Sclerophyllus)

Tanoak (Lithocarpus densiflorus)
Chinkapin (Castanopsis chrysophylla)
Canyon Live Oak (Quercus chrysolepis)
Pacific Madrone (Arbutus menziesii)
Narrow-leaf Buckthorn (Ceanothus cuneatus)
Snowbrush or Varnishleaf (C. veluntinus)
Pine Mat Manzanita (Arctostophylos nevadensis)
Hoary Manzanita (A. canescens)
White Leaved Manzanita (A. viscida)
California Coffee Berry (Rhamnus californica)
Birchlead Mountain Mahogany (Cereocarpus betuloides)

Deciduous

Oregon White Oak (Quercus garryana)
California Black Oak (Q. Kelloggii)
Redstem Ceanothus (Ceanothus sanguineus)
Deerbrush Ceanothus (C. integerrimus)
Pale Serviceberry (Amelanchier pallida)
Skunkbrush Sumac (Rhus trilobata)
Poison Oak (Rhus diversiloba)

Vegetation typical of the Broad Sclerophyll frequently occurs outside the sub-biome as an intermediate stage of plant succession where a later stage will be coniferous forest: such an area is however considered as the Montane Coniferous Forest rather than Broad Sclerophyll. It is often very difficult to determine whether a community on a given site is climax or intermediate (seral).

Northwest Coastal Coniferous Forest. This is the most densely forested of the two coniferous forest sub-biomes. The forests generally regenerate easily, grow rapidly and reach impressive sizes. The lower vegetative layers are usually poorly developed except at dry sites where open canopies encourage growth of lush understory of shrub and herbaceous layers.

Plant succession following removal of forest vegetation, usually proceeds through three stages; (1) rapid growth of residual and invading herbaceous plants (such as grasses and ferns), (2) gradual development into a shrub dominated condition, and (3) development of the young growth forest. Stages one or two, or both, may not occur depending upon environmental factors. Either of the first two stages may also dominate for exceedingly long periods of time, also due to environmental factors.

Franklin and Dyrness have identified five major vegetative (climax) zones within the sub-biome that are dominated by coniferous vegetation; they include (1) the coastal "Sitka Spruce Zone", (2) the widespread inland low to mid-elevational "Western Hemlock Zone", (3) the higher elevational "Pacific Silver Fir Zone", (4) the sub-alpine "Mountain Hemlock Zone" and (5) "Timberline" (Figure 8). These vegetation zones reflect climatic conditions inherent with elevational differences that occur throughout the Northwest Coastal area. The "Sitka Spruce Zone" where snow seldom occurs, for example, is the mildest in Oregon, while the "Mountain Hemlock Zone" is one of the coldest.

Major tree species and their occurrence within the major zones are estimated in Table 3.

FIGURE NO. 8

GENERAL LOCATION MAP

CONIFEROUS FOREST ZONES

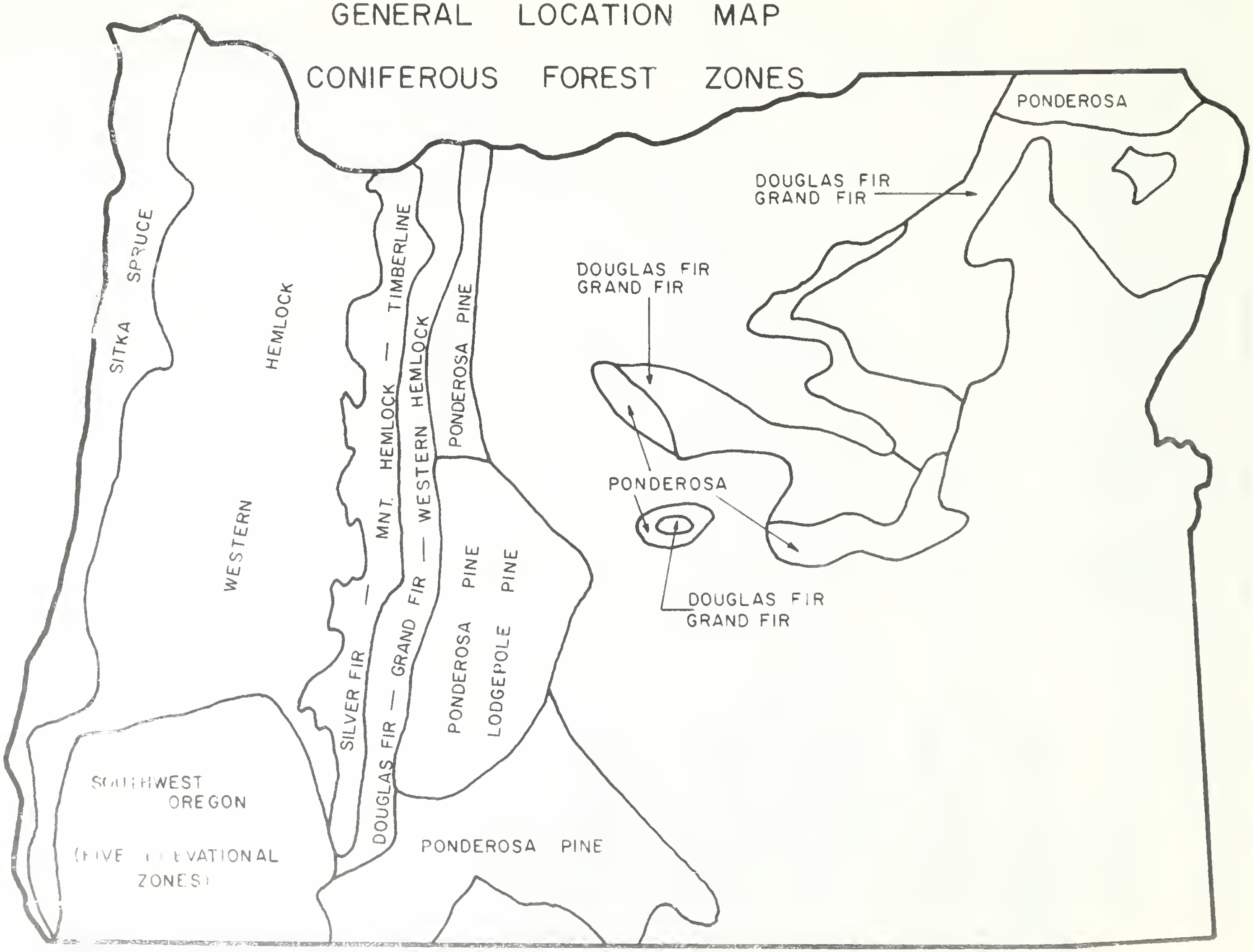


Table 3 - Northwest Coastal Sub-Biome
Major Species Occurrence By Zones 1/

Species	Sitka Spruce 2/	Western Hemlock 2/	Pacific Silver Fir	Mountain Hemlock	Timber-line
Western White Pine (Pinus monticola)	4	3	2	3	4
Sugar Pine (Pinus lambertiana)	4	3	3	3	4
Whitebark Pine (Pinus albicaulis)	4	4	4	2	1
Lodgepole Pine (Pinus contorta)	1	4	2	3	3
Ponderosa Pine (Pinus ponderosa)	4	4	4	4	4
Western Larch (Larix occidentalis)	4	4	3	3	4
Engelmann Spruce (Picea engelmannii)	4	4	2	2	2
Sitka Spruce (Picea sitchensis)	2	3	4	4	4
Western Hemlock (Tsuga heterophylla)	1	1	2	3	4
Mountain Hemlock (Tsuga mertensiana)	4	4	2	2	2
Douglas-fir (Pseudotsuga menziesii)	1	1	2	3	4
Grand Fir (Abies grandis)	2	2	3	4	4
Pacific Silver Fir (Abies amabilis)	4	3	1	2	3
White Fir (Abies concolor)	4	4	4	4	4
Noble Fir (Abies procera)	4	3	2	3	4
Shasta Red Fir (Abies magnifica)	4	4	3	3	3
Subalpine Fir (Abies lasiocarpa)	4	4	2	2	2
Redwood (Sequoia sempervirens)	2	4	4	4	4
Incense Cedar (Libocedrus decurrens)	3	2	3	4	4
Western Redcedar (Thuja plicata)	2	2	3	4	4

1/ 1 = abundant, 2 = common, 3 = uncommon, 4 = rare or absent
2/ Zones containing significant amounts of BLM acreage

The "cool-moist", "warm-dry" dichotomy relates to plant succession following removal of the coniferous forest. There is, for example, an especially strong tendency towards development of dense, semi-permanent shrub and hardwood communities, that exclude or limit conifers, on relatively "cool-moist" sites within the Sitka Spruce Zone. On relatively "warm-dry" sites in the Western Hemlock Zone however, the tendency is towards exclusion of conifers during a period of dominance by herbaceous plants, especially following clearcutting and burning.

Port-Orford-cedar (Chamaecyparis lawsoniana) is a natural component of timber stands on sites of almost any moisture regime in extreme southwestern Oregon. It is currently endangered by a killing root disease, however, to the extent that is has nearly been eliminated from moist sites and could possibly be eliminated from most of its natural range.

Montane Coniferous Forest. Forests of this sub-biome generally reproduce with difficulty or grow slowly, have relatively open canopies, and tend to have sparse understory, shrub and herbaceous layers (exceptions are commonplace). Plant succession following removal of the forest in this sub-biome usually follows the three stages outlined for the Northwest Coastal Coniferous Forest; i.e., herbs, to shrubs, to conifers. Also as in the Northwest Coastal Coniferous Forest, one or both of the first two stages may not occur on any given area, or may persist for an exceedingly long period of time.

This region may be viewed as having five major zones of tree species which reflect climatic conditions inherent with elevational differences. From low to high elevation these zones are: (1) "Mixed Conifer and Mixed Evergreen", (2) "White Fir", (3) "Red Fir", (4) "Mountain Hemlock", and (5) "Timberline". The lowest zone, the "Mixed Conifer and Mixed Evergreen" is warm and dry while higher zones, such as the "Red Fir" and "Mountain Hemlock" zones are cool and moist. Major tree species found within the major zones are estimated on Table 4.

Plant succession is normally slow following removal of forest on relatively "warm-dry" sites in "Mixed Conifer and Mixed Evergreen" and "White Fir" zones; establishment of coniferous seedlings may require as much as 25 years or more. Plant succession on relatively "cool-moist" sites, however, is normally more rapid provided other interferring conditions, such as animal damage, are not limiting.

Table 4 - Montane Sub-Biome
Major Species Occurrence By Zone 1/
S.W. Oregon Region

Species	2/ Mixed C. or E.	2/ White Fir	Red Fir	Mountain Hemlock	Timber-line
	ZONES				
Western White Pine (Pinus monticola)	3	3	3	3	4
Sugar Pine (Pinus lambertiana)	2	3	3	3	4
Whitebark Pine (Pinus albicaulis)	4	4	3	2	1
Lodgepole Pine (Pinus contorta)	3	3	3	3	2
Ponderosa Pine (Pinus ponderosa)	2	3	4	4	4
Jeffrey Pine (Pinus jeffreyi)	3	3	4	4	4
Engelmann Spruce (Picea engelmannii)	4	4	3	3	3
Western Hemlock (Tsuga heterophylla)	3	4	4	4	4
Mountain Hemlock (Tsuga mertensiana)	4	4	3	1	2
Douglas-fir (Pseudotsuga menziesii)	2	2	4	4	4
Grand fir (Abies grandis)	3	4	4	4	4
Pacific Silver Fir (Abies amabilis)	4	3	2	4	4
White Fir (Abies concolor)	2	1	3	4	4
Noble Fir (Abies procera)	4	4	3	4	4
Shasta Red Fir (Abies magnifica var. shastensis)	4	3	1	2	3
Subalpine Fir (Abies lasiocarpa)	4	4	3	2	2
Incense Cedar (Libocedrus decurrens)	2	2	3	4	4
Western Redcedar (Thuja plicata)	3	3	4	4	4

1/ 1 = abundant, 2 = common, 3 = uncommon, 4 = rare or absent
2/ Zones containing significant amounts of BLM acreage

A notable successional characteristic within these zones is a strong tendency towards development of extensive, dense brushfields of dry-site species and subsequent delay in establishment of coniferous seedlings, especially where fire has occurred. Species common to this successional stage are often those typical of the Broad Sclerophyll.

Aquatic Animals

Large indigenous populations of salmon and trout have always been the principal species of aquatic wildlife utilized by man in western Oregon. Native production of salmon and trout has decreased drastically in the last century because of adverse habitat changes caused by irrigation, agriculture, logging, and pollution. Entire races of anadromous fish have been eliminated by water projects that blocked fish runs to hundreds of miles of productive habitat. To compensate for decreasing natural production, intensive artificial propagation programs by State and Federal fishery agencies have been implemented in recent years. This increased hatchery production of salmon and trout is making substantial contributions to the fisheries.

Distribution of fishes in western Oregon, as described in this statement, is based on information from Oregon State University, reports of the Pacific Northwest River Basins Commission, and both Basin Investigation reports and Annual Reports of the Fishery Division of the Oregon State Wildlife Commission. Common and scientific names listed are those recommended by the American Fisheries Society.

A checklist of freshwater fishes is shown by sub-biome in Table 5. These species occur in waters west of the crest of the Cascade Mountains and part of the Klamath Basin. The greatest number of species inhabit the Northwest Coastal Coniferous Forest sub-biome because it comprises most of western Oregon and has greater diversity of habitat than the other sub-biomes.

Fish in Oregon are generally grouped into the following five categories: anadromous fish*, cold-water game fish, warm-water game fish, non-game fish, and surf and bay fish. Marine species are not discussed in detail in this report.

* Anadromous fish are hatched in freshwater, migrate as juveniles to the ocean to grow and mature, and return as adults to freshwater to spawn.

Table 5 - A Checklist of Freshwater Fishes in Western Oregon by Sub-biome

Species	NW Coastal Forest	Montane Forest	Broad Sclerophyll	Palouse Prairie
ANADROMOUS SPECIES				
Pacific lamprey (lampetra tridentata)	X	X	X	X
White sturgeon (Acipenser transmontanus)	X	X	X	
American shad (Alosa sapidissima)	X	X	X	
Cutthroat trout (Salmo clarki clarki)	X	X	X	X
Steelhead (Salmo g. gairdneri)	X	X	X	X
Sockeye salmon (Oncorhynchus nerka)	X			
Chum salmon (Oncorhynchus keta)	X			
Coho salmon (Oncorhynchus kisutch)	X	X	X	X
Chinook salmon (Oncorhynchus tshawytscha)	X	X	X	X
Pink salmon (Oncorhynchus gorbuscha)	X			
Eulachon (Thaleichthys pacificus)	X			
Longfin smelt (Spirinchus thaleichthys)	X			
Striped bass (Morone saxatilis)	X			
COLD-WATER GAME SPECIES				
Mountain whitefish (Prosopium williamsoni)	X			
Brook trout (Salvelinus fontinalis)	X	X	X	
Dolly Varden (Salvelinus malma)	X			
Cutthroat trout (Salmo clarki)	X	X	X	X
Brown trout (Salmo trutta)	X	X	X	
Golden trout (Salmo aguabonita)	X			
Rainbow trout (Salmo gairdneri)	X	X	X	X

Species	NW Coastal Forest	Montane Forest	Broad Sclerophyll	Palouse Prairie
COLD-WATER GAME SPECIES (Cont.)				
Kokanee (Oncorhynchus n. kennerlyi)	X	X	X	
Lost River sucker (Catostomus luxatus)		X		
Burbot (Lota lota)	X			
WARM-WATER GAME SPECIES				
White catfish (Ictalurus catus)	X			
Channel catfish (Ictalurus punctatus)	X			
Yellow bullhead (Ictalurus natalis)	X			
Brown bullhead (Ictalurus nebulosus)	X	X	X	X
White crappie (Pomoxis annularis)	X	X	X	X
Black crappie (Pomoxis nigromaculatus)	X	X	X	X
Pumpkinseed (Lepomis gibbosus)	X	X	X	X
Bluegill (Lepomis macrochirus)	X	X	X	X
Warmouth (Lepomis gulosus)	X			
Green sunfish (Lepomis cyanellus)	X	X		
Largemouth bass (Micropterus salmoides)	X	X	X	X
Smallmouth bass (Micropterus dolomieui)	X			
Walleye (Stizostedion vitreum vitreum)	X			
Yellow perch (Perca flavescens)	X	X	X	
NON-GAME SPECIES				
Pit-klamath brook lamprey (Lampetra lethophaga)		X		
River lamprey (Lampetra ayresi)	X			
Western brook lamprey (Lampetra richardsoni)	X	X	X	X

Species	NW Coastal Forest	Montane Forest	Broad Sclerophyll	Palouse Prairie
NON-GAME SPECIES (Cont.)				
Mountain sucker (Catostomus platyrhynchus)	X			
Bridgelip sucker (Catostomus columbianus)		X		
Klamath smallscale sucker (Catostomus rimiculus)		X	X	X
Largescale sucker (Catostomus macrocheilus)	X	X	X	X
Klamath largescale sucker (Catostomus synderi)		X	X	
Shortnose sucker (Chasmistes brevirostris)		X		
Carp (Cyprinus carpio)	X	X	X	X
Tench (Tinca tinca)	X			
Chiselmouth (Acrocheilus alutaceus)	X			
Oregon chub (Hybopsis crameri)	X	X	X	
Northern squawfish (Ptychocheilus oregonensis)	X			
Umpqua squawfish (Ptychocheilus umpquae)	X	X	X	
Redside shiner (Richardsonius balteatus balteatus)	X	X	X	X
Blue chub (Gila coerulea)		X		
Tui chub (Gila bicolor)		X	X	
Umpqua dace (Rhinichthys evermanni)	X	X	X	
Longnose dace (Rhinichthys cataractae dulcis)	X			
Speckled dace (Rhinichthys osculus)	X	X	X	X
Blackside dace (Rhinichthys o. nubilus)	X	X	X	X
Leopard dace (Rhinichthys falcatus)	X			
Millicoma dace (Rhinichthys sp.)	X			

Species	NW Coastal Forest	Montane Forest	Broad Sclerophyll	Palouse Prairie
Peamouth (Mylocheilus caurinus)	X			
Rainwater killifish (Lucania parva)	X			
Mosquitofish (Gambusia affinis)	X	X		
Sand roller (Percopsis transmontana)	X			
Slender sculpin (Cottus tenuis)		X		
Coastrange sculpin (Cottus aleuticus)	X	X	X	
Klamath Lake sculpin (Cottus princeps)		X		
Prickly sculpin (Cottus asper)	X	X	X	X
Riffle sculpin (Cottus gulosus)	X	X	X	
Shorthead sculpin (Cottus confusus)	X			
Torrent sculpin (Cottus rhotheus)	X			
Mottled sculpin (Cottus bairdi semiscaber)	X			
Piute sculpin (Cottus beldingi)	X			
Marbled sculpin (Cottus klamathensis)		X		
Reticulate sculpin (Cottus perplexus)	X	X	X	X
Three-spined stickleback (Gasterosteus aculeatus)	X	X	X	

Various subspecies of both rainbow and cutthroat trout have been reared in hatcheries and at one time or another planted in most easily accessible waters of western Oregon to improve angling.

Cold-water game fish require colder water temperatures (below 70°F) and the best water quality to maintain healthy populations. They are most numerous in streams and lakes of the Coniferous Forest, but occur in all sub-biomes where habitat is suitable. Young salmon and steelhead require the same water quality conditions that cold-water game fish prefer.

Some resident trout, kokanee, whitefish, mullet and lampreys exhibit seasonal intra-stream migrations for spawning in many stream and lake systems.

Young trout and salmon are primarily insect feeders. As they grow and become larger, a greater variety of organisms are eaten, including crustaceans and terrestrial insects that fall into streams. Mature individuals become quite predaceous on small fish, especially Dolly Varden and brown trout. An abundant population of salmonid species is therefore dependent upon a healthy food chain consisting of many small animals that feed on aquatic plants. Good water quality and habitat conditions are essential to maintain the food chain.

Warm-water game fish have been widely introduced throughout western Oregon in all types of aquatic habitat. They may be caught unexpectedly in some waters, the result of illegal introduction. These species require warmer water temperatures (75°-85°F) than trout for reproduction. They are also more tolerant of adverse habitat conditions than are salmon and trout, e.g., lower dissolved oxygen concentrations or increased turbidity. They are more prolific then cold-water species and usually cause fishery management problems when introduced into waters managed for trout or salmon production. Because they will thrive in a wide range of habitat conditions and degraded waters, these species provide recreation in some waters unsuited for cold-water fishes.

Native non-game species like shiners, dace, suckers, chubs and squaw-fish, and the introduced carp can cause serious management problems to fishery managers. Populations of non-game fish tend to "explode" and over-populate waters being managed for game fish. In many waters, non-game fish are too competitive (especially for cold-water species), particularly if habitat and water quality conditions are being degraded. Endemic non-game fish are of scientific interest.

Surf and bay fish include seaperch, rockfish, greenling, flounder, sturgeon, sculpin, herring and smelt. These fish are usually found in a marine habitat.

Rare and endangered fish are cataloged by both the State of Oregon and by the Bureau of Sport Fisheries and Wildlife. The Lost River and

shortnose suckers are the only species found in western Oregon classified nationally as possibly threatened with extinction (referred to as "status-undetermined") because not enough information is available to determine their status. Rare and endangered species listed by the State of Oregon indigenous to western Oregon are:

Millicoma dace (Rhinichthys sp.) - Coos River; endangered.
Shortnose sucker - Upper Klamath Lake and tributaries; endangered.
Pit-Klamath brook lamprey (Lampetra lethophaga) - Klamath drainage; rare.

Fish are usually considered the most important group of aquatic life because of their direct use to man. However, there are many other aquatic animals that are important because they either provide minor direct benefits to man or contribute to the aquatic food chain and other complex ecological relationships in aquatic ecosystems. Some of the more important groups include:

Crustacea - shrimp, crayfish and crabs.
Pelecypoda - clams, oysters and mussels.
Insecta - mayflies, stoneflies and caddisflies.

Northwest Coastal Coniferous and Montane Coniferous Forests. The two coniferous forest sub-biomes cover most of western Oregon. They produce most of western Oregon's water supply, which is generally of high quality in mountainous areas. Most streams and rivers produce near neutral water of low temperatures and a fair number of aquatic animals. However, significant changes in water quality may occur at lower elevations. Water temperatures often increase substantially during the summer low flow period and water quality is further degraded by pollutants. Extreme water withdrawals for irrigation contribute to higher temperatures and some dry streambeds throughout the biome. These habitat changes are deleterious to trout and salmon but beneficial to populations of warm-water and non-game species.

Historically, some of the best anadromous fish habitat on the west coast of North America was located in these sub-biomes. The Rogue, Umpqua and Willamette Rivers and Tenmile Lakes are notable examples. Other coastal rivers like the Nehalem, Nestucca, Alsea, Coos and Tillamook Bay streams also produce large numbers of fish. Deleterious habitat changes, introductions of warm-water and non-game fish, and blocked access (primarily by dams) to many miles of streams have each caused reductions in the natural runs of anadromous fish.

Salmon and anadromous trout are still widespread throughout the Coniferous Forest Biome, occurring wherever their access is not blocked by impassable obstructions--either natural (water falls) or man-made (dams or log jams). Because of the life requirements of anadromous fish, special efforts are needed to keep migration routes open and to maintain good quality water in spawning and rearing areas for remaining fish populations.

Other aquatic organisms, as well as fish, have adapted to good quality water, food and cover. Most organisms of this biome require stream habitat that is relatively free of fine silt, sand or clays. Benthic organisms, crustacea and aquatic insects require larger substrate like rubble and gravel.

Clean, silt-free gravel is important to many organisms and especially for salmon and trout spawning. Gravel between 1/2 to 5 inches in diameter is required, depending on the species of fish. Hatching success is drastically reduced by heavy sedimentation of spawning areas.

The following water requirements are considered optimum for aquatic life in these sub-biomes:

Water temperature - 50° to 60° F. (summer)
Dissolved oxygen - 7 to 9 ppm
Hydrogen Ion (pH) - 6.8 to 7.8 ppm
Total dissolved solids - 150 ppm
Jackson turbidity units - 5 or less (summer)

Smaller organisms such as aquatic insects are less tolerant to water quality changes than many fish.

Adequate streamside vegetation is very important to the aquatic ecosystem. The vegetation stabilizes streambanks preventing erosion and sedimentation. Vegetation also provides protective cover for fish and other life. Shade from higher vegetation is a key factor in maintaining the low water temperature characteristic of most streams in the biome.

<u>Northwest Coastal Coniferous Forest and Montane Coniferous Forest</u> sub-biomes contain many important fish-producing lakes and reservoirs. These waters are generally more fertile than rivers and streams unless the basins lose nutrients by periodic flushing. With intensive management, some lakes, like Diamond Lake, consistantly produce hundreds of thousands of trout annually to angler creels.

Although native runs of anadromous fish have been greatly reduced from historic levels, natural production is still vital to various fisheries in Oregon. Fish produced in freshwater are caught as adults in the Pacific Ocean, estuaries and main river systems. Coastal lakes provide habitat for salmon, trout and warm-water game fish. There are numerous reservoirs in the Willamette system now creating habitat for various species, depending on the characteristics of each reservoir.

The most important anadromous species are Chinook and Coho Salmon, and steelhead and coastal cutthroat trout. Chum salmon spawn in tributaries to the lower Columbia River and in many coastal rivers in decreasing numbers in central and southern Oregon. Pink salmon enter the lower Columbia River and occasionally stray into coastal streams. An annual run

of sockeye salmon migrates through the lower Columbia River in June and July, and experimental plants of sockeye have been made in recent years in some reservoirs in Willamette drainage.

Both white and green sturgeon inhabit the lower Columbia River and other estuaries. White sturgeon also frequent lower reaches of coastal rivers and some lakes. Green sturgeon seldom migrate above tidewater. American shad and striped bass also occur in some larger coastal rivers and the Columbia River.

Large runs of Columbia River smelt or Eulachon enter the Columbia River annually and occasionally the Sandy River and some coastal streams. This species does not migrate over Bonneville Dam. Longfin smelt occasionally enter freshwater from estuaries during fall months. The Pacific lamprey enters most coastal rivers as well as the Columbia River.

Resident rainbow and cutthroat trout are common to the sub-biomes. Kokanee have been stocked in many reservoirs. Whitefish are found in colder streams and some reservoirs at higher elevations in the Cascade Mountains. Brown, brook and Dolly Varden trout are limited to a few specific areas. Golden trout (Salmo aquabonita) are stocked in some high Cascade lakes.

The Oregon chub is the only Hybopsis native to the Pacific Coast. Other non-game fish with a restricted distribution are the Umpqua dace (Umpqua River and tributaries) and the Umpqua squawfish (Umpqua and Siuslaw Rivers and intervening waters). The rare Millicoma dace is found only in the Coos River. The river lamprey (Lampetra ayresi) occurs only in the Northwest Coastal Coniferous Forest and is uncommon.

A commercial fishery for crayfish is conducted primarily in these sub-biomes with the catch composed of two subspecies--Pacifastacus leniusculus leniusculus and P.I. trowbridgii. About 39,000 pounds of crayfish were processed through commercial channels in Oregon during 1970. In many waters people catch crayfish to eat. Sport fishermen use crayfish for fish bait.

Estuaries are the lower portions of rivers that are directly influenced by ocean tides. Coos Bay and Tillamook Bay are examples of large well-developed estuaries. These tidal areas where salt and freshwater mix are very productive habitats for many aquatic species. Estuaries are breeding and nursery grounds for many species of fish and other aquatic life.

Oregon's major bays have been heavily industrialized and serve as harbors for shipping and commercial and sport fishing fleets. Sandy beaches and rocky shorelines provide exceptional recreational opportunities, including fishing and clam digging.

Dungeness crabs (Cancer magister) are numerous in most bays and they are eagerly sought as a sport catch. This species also supports an important commercial fishery.

The native oyster (Ostrea lurida) and Japanese oyster (Crassostrea gigas) are cultured by private oyster growers in some estuaries.

Razor clams (Siliqua patula) are abundant on the Clatsop County beaches. Only a few isolated populations of razor clams occur on other beaches. Bay clams are abundant in certain areas of some coastal bays. Important species are the gaper clam (Schizothaerus nuttalli), cockle (Clinocardium nuttalli), softshell clam (Mya arenaria), butter clam (Saxidomus giganteus), and Littleneck clam (Protothaca staminea).

Bay and razor clams, ghost shrimp (Callianassa), and mud shrimp (Upogebia) are sold commercially. Populations of bay and razor clams support very intensive sport digging. Sport fishermen commonly dig shrimp for fish bait.

Broad Sclerophyll. The Broad Sclerophyll sub-biome encompasses scattered areas within the Montane Forest of southwestern Oregon. Because of this geographical situation, most species reported for the Montane Forest are probably found in waters that are part of the Broad Sclerophyll.

Palouse Prairie Grassland. The Palouse Prairie sub-biome in western Oregon is limited to a small isolated area of the Bear Creek and Rogue River valleys. Most of the original grassland has been drastically altered by agriculture and other activities of man. Warm water temperatures, pollution, and irrigation withdrawals cause serious water quality problems for cold-water species during summer months in Bear Creek, parts of the Rogue River, and other streams in the sub-biome. Water quality and flow are normally adequate in these streams for attraction of anadromous species during the migration period.

This sub-biome intermingles with the Broad Sclerophyll, and the majority of species listed for the Broad Sclerophyll also occur in the Palouse Prairie.

Terrestrial Animals

A wide variety of terrestrial animals is found in western Oregon since under pristine conditions, the basic requirements of food, water, cover and space are usually well met for most species. Some animal species are represented in all sub-biomes. Others, more specific in their requirements, are found in only one or two. The following representative terrestrial wildlife families are generally found in western Oregon.

Mammals

Deer - (Cervidae)
Bears - (Ursidae)
Coyotes & Foxes - (Canidae)
Squirrels - (Sciuridae)
Mice & Rats - (Cricetidae)
Beavers - (Castoridae)
Wildcats & Cougar - (Felidae)
Rabbits & Hares - (Leporidae)
Weasels - (Mustilidae)
Bats - (Vespertilionidae)
Shrews - (Soricidae)

Birds

Hawks & Eagles - (Accipitridae and Falconidae)
Vulture - (Cathartidae)
Owls - (Tytonidae and Strigidae)
Jays, Magpies & Crows - (Corvidae)
Grouse - (Tetraonidae)
Ducks, Geese - (Anatidae)
Woodpeckers - (Picidae)
Wrens - (Troglodytidae)
Finches & Sparrows - (Fringillidae)

Reptiles & Amphibians

True toads - (Bufonidae)
True frogs - (Ranidae)
Garter & Gopher snakes - (Colubridae)
Lizards - (Anguidae)

Insects

Grasshoppers - (Acrididae)
Wasps & Hornets - (Vespidae)
Ants - (Formicidae)

—Rare and Endangered Wildlife. The following species found in western Oregon are listed as rare or endangered, nationally, by the Bureau of Sport Fisheries and Wildlife. In some cases, the habitat is quite restricted.

Columbian white-tailed deer - (Odocoileus virginianus leucurus)
American peregrine falcon - (Falco peregrinus anatum)
Arctic peregrine falcon - (Falco peregrinus tundrius)

In addition to the species listed as rare or endangered nationally, the State of Oregon lists the following wildlife as rare or endangered in Oregon. In some cases, the habitat is confined to a small area.

Mammals

Wolverine - (Gulo luscus)
Sea otter - (Enhydra lutris)
Northern elephant seal - (Mirounga angustirostris)
Ashland shrew - (Sorex trigonirostris)
Brazilian free-tailed bat - (Tadarida brasiliensis)
White-footed vole - (Aborimus albipes)
Ringtailed cat - (Bassariscus astutus)
Fisher - (Martes pennanti)

Birds

Ferruginous hawk - (Buteo regalis)
Northern bald eagle - (Haliaeetus leucocephalus)
Flammulated owl - (Otus flammeolus)
Northern spotted owl - (Strix occidentalis caurina)
Western snowy plover - (Charadrius alexandrimus nivosus)
Great gray owl - (Strix nebulosa)
Alaska northern three-toed woodpecker - (Picoides tridacylus)

Amphibians and Reptiles

Cope's giant salamander - (Dicamptodon copei)
Larch mountain salamander - (Plethodon larselli)
Siskiyou mountain salamander - (Plethodon stormi)
Oregon slender salamander - (Batrachoseps wrighti)
Black salamander - (Aneides flavipunctatus)
Tailed frog - (Ascaphus truei)
Western spotted frog - (Rana pretiosa pretiosa)
Sharp-tailed snake - (Contia tenuis)

Beside consumptive use, thousands of outdoor recreationists enjoy wildlife photography, viewing, and other forms of non-consumptive recreation. Thousands of migrating waterfowl and shore birds utilize Oregon waters from the coast to the Willamette Valley for feeding and resting on their flights to and from northern breeding areas. These bird concentrations provide an excellent opportunity for bird-watching and photography.

While consumptive and non-consumptive wildlife use increases, populations appear to be decreasing in many parts of the State. Loss of some northern breeding habitat for waterfowl, a loss of nesting and wintering cover for some species of upland game birds, and the impact of severe winters and marginal winter range conditions on big game species have reduced population of both game birds and animals. Clean farming practices, instances of overgrazing and overcutting of timber, changing land use patterns, and increased recreational use of former "wild" lands have also reduced non-game bird and animal numbers through loss of habitat.

Forest Sub-biomes - General Habitat Requirements. Wildlife typical of the forests are generally adapted to a closed canopy of coniferous timber interspersed with small openings. Some species, including the herbivores, such as deer and elk, respond to an edge effect created by forest meadows, logging, or fires that allow development of a nutritious understory of vegetation. Other species, including the raptors and larger predators, may respond adversely to loss of the timber overstory, especially if it is accompanied by human activity. Accipter hawks and the horned and northern spotted owls depend on tree-dwelling mammals for their prey, the redbacked mouse, red and flying squirrels, and the small birds that are found in forested areas. Bald eagles and ospreys need dead and dying trees adjacent to lakes, streams, and the ocean for nest sites since their prey is principally fish.

Many fur-bearers and birds are adapted to a semi-aquatic habitat, and the presence of streams, lakes and ponds adds greatly to the variety of wildlife. Permanent supplies of clean water should be available to wildlife at all times. In a so-called "virgin forest" this is usually not a limiting factor. Most forest wildlife can adapt to certain habitat changes, but these changes can be detrimental to many species when accompanied by human activity.

Northwest Coastal Coniferous Forest. The Northwest Coastal Forest grows in an area where water is usually not a severe limiting factor. Humidity is high and the temperature range is narrow. There is usually a deep layer of duff and organic soil rich in micro-organisms. The huge trees produce dense shade resulting in a poorly developed understory of nutritious browse species. Common animals include:

Mammals

Roosevelt elk - (Cervus canadensis roosevelti)
Blacktailed deer - (Odocoileus hemionus columbianus)
Black bear - (Euarctos americanus)
Bobcat - (Lynx rufus)
Cougar - (Felis concolor)
Mtn. Beaver (Sewellel) - (Aplodontia rufa)
Pocket gopher - (Thomomys hesperus)
Brush rabbit - (Sylvilagus bachmani ubericolor)
Douglas chickaree - (Sciurus douglasii)
Red tree mouse - (Phenacomys longicaudus)
Northwest coast bat - (Myotis californicus caurinus)

Birds

Pacific horned owl - (Bubo virginianus pacificus)
Northern spotted owl - (Strix occidentalis caurina)
Cooper's hawk - (Accipter cooperi)
Bald eagle - (Haliaeetus leucocephalus)

Blue grouse - (Dendragapus obscurus)
Winter wren - (Nannus hiemalis pacificus)
Band-tailed pigeon - (Columbia fasciata fasciata)
Pileated woodpecker - (Ceolophloeus pileatus)
Townsend's Warbler - (Dendroica townsendi)

Amphibians and Reptiles

Pacific giant salamander - (Dicamptodon ensatus)
Puget Sound garter snake - (Thamnophis sirtalis)
Pacific rubber boa - (Charina bottae)

Other wildlife are found in more specific zonal types: the hemlock looper (Ellopia fascellaria lugubrosa) and the Sitka spruce beetle (Dendroctonus obesus) are serious defoliators.

In the Coastal Douglas-fir zone, the Trowbridge's shrew (Sorex trowbridgii t.), and insectivore, feeds on Douglas-fir seed.

The Larch Mountain salamander, considered endangered by the State of Oregon, is found in the north Cascades.

The fisher (Martes pennanti) and the rare flammulated owl, (Otus flammeolus) are found in the forested areas below timberline.

The wolverine, also considered endangered by the State, is found in alpine habitat.

The endangered Oregon white-tailed deer is found in the Roseburg area and along the bottomlands of the lower Columbia River.

—Habitat Requirements. This sub-biome has the ability to produce desirable habitat following fires, logging, and other disturbances to the overstory more rapidly than Montane forests due to better soils, moisture conditions and lower elevations. Water is not usually a limiting factor.

Deer and elk generally follow any natural or man-made opening in the dense overstory, such as caused by fires or logging, to take advantage of resulting nutritious ground vegetation. Closed canopy forests that provide winter cover and escape shelter are a crucial part of game animal habitat.

The cougar and black bear inhabiting this sub-biome are wilderness species that need the seclusion and escape cover afforded by dense forests.

Many of the small mammals, birds, and amphibians found in coastal forests depend on the variety of insect life that abounds in the damp mild environment, as well as the great mass of seeds produced by evergreen trees.

Mink, marten, otter, beaver, and muskrat favor this habitat due to the proximity of lakes and streams that afford food, bank dens, and travel routes. While waterfowl are not normally considered as representative birds of timbered habitat, many ducks use the lakes, rivers, and estuaries adjacent to the moisture-holding forest lands. Some ducks, including the golden-eye, bufflehead, and wood duck, nest in tree cavities adjacent to water.

In addition to the terrestrial wildlife listed for the Northwest Coastal Coniferous Forest many forms of aquatic and semi-aquatic wildlife (birds and mammals) inhabit the estuaries and immediate coastal zone. These include the following:

Mammals

Sea otter - (Enhydra lutris)
Pacific harbor seal - (Phoca vitulina)
Stellar sea lion - (Eumetopias jubata)
California sea lion - (Zalophus californianus)

Birds

Common loon - (Gavia immer)
Brown pelican - (Pelicanus occidentalis)
Brandt's cormorant - (Phalacrocorax penicillatus)
Western grebe - (Aechmophorus occidentalis)
Red-breasted merganser - (Mergus serrator)
Least sandpiper - (Pisobia minutilla)
Sanderling - (Crocethia alba)
Northwest coast heron - (Ardea herodias)
Western gull - (Larus occidentalis)
Common murre - (Uria aalge)
Black brant - (Branta nigricans)
Surf scoter - (Melanitta perspicillata)

Many other species of shorebirds and waterfowl use this important coastal habitat as residents or migrants. The northern bald eagle and osprey are also often found along rivers, bays and estuaries. These species are dependent on fresh, brackish, or salt water and the adjacent beaches or mudflats for their immediate habitat or for the plants or animals that constitute their food supplies.

Montane Coniferous Forest. A greater variety of habitat exists in this sub-biome than in the coastal forest, due to the variety of vegetative types. This allows a high degree of use by adaptable wildlife. Representative species include:

Mammals

Blacktailed deer - (Odocoileus hemionus columbianus)
Golden-mantled ground squirrel - (Citellus lateralis)
Pika - (Ochotona princeps)
Snowshoe hare - (Lepus americanus)
Big free tailed bat - (Tadarida molossa)

Birds

Barrow's golden eye - (Glancionetta islandica)
Great gray owl - (Strix nebulosa)
Oregon jay - (Perisoreus obscurus)
Three-toed woodpecker - (Picoides tridactylus)
Red-tailed hawk - (Buteo borealis)
Clark's nutcracker - (Nucifraga columbiana)
Mountain quail - (Oreortyx pictus)

Amphibians and Reptiles

Pacific tree frog - (Hyla regilla)
California mountain kingsnake - (Lampropelis zonata)

Insects

Oregon rain beetle - (Plecoma oregonensis)

As with the coastal forest sub-biome, many other wildlife species are found by regions of the Montane Forest such as the rare black salamander.

In the Cascades, the Roosevelt elk and Rocky Mountain elk have intermingled until it is difficult to differentiate between the two sub-species. Parts of this zone may have mule deer concentrations as well as blacktailed deer populations. The Beechey ground squirrel (Spermophilis beecheyi) is common in the mixed forests of this area as is the Northern Pacific rattlesnake (Crotalis virdis). Destructive beetles, such as the bark beetle (Ips emarginatus) infest Ponderosa pine.

——Habitat Requirements. Water can be a limiting factor in portions of this sub-biome. The diversity of habitat and climatic conditions produces a diversity of wildlife. Woodpeckers make extensive use of the oaks and other hardwoods found in parts of this sub-biome for food, food storage and nesting. Many other birds and small animals also use cavities in dead and dying trees as nest and den sites. The many herbivores inhabiting this sub-biome utilize most of the upper areas as summer range. Deep snows and cold preclude year-round residency for some species such as deer and elk. These ruminants must have suitable winter range within reasonable migration distance for survival.

As noted for other timbered areas, the larger predators--wolverine, bear, and cougar--must have the privacy of wilderness to survive.

Broad Sclerophyll. A portion of the Montane Coniferous Forest merges with hardwood trees and brush in southwestern Oregon. The Broad Sclerophyll sub-biome adjacent to the Siskiyou, Klamath, and Cascade Mountains contains many important wildlife species more closely related to California forms than to the Rocky Mountain species. Wildlife species include:

Mammals

Dusky footed woodrat - (Neotoma cinerea)
Oregon gray fox - (Urocyon cinereoargenteus)
Ringtailed cat - (Bassariscus astutus)
Pacific pale bat - (Antrozous pallidus)

Birds

Valley quail - (Lophortyx californica)
California jay - (Aphelocoma californica)
Sacramento towhee - (Pipilo maculatus)
Red-shafted flicker - (Colaptes cafer)
Acorn woodpecker - (Melanerpes formicivorus)

Amphibians and Reptiles

Sharp-tailed snake - (Contia tenuis)
Siskiyou Mountain salamander - (Plethodon stormi)

The Broad Sclerophyll is an extension of the transition zone of central Oregon, and some of the wildlife found along the fringes of the Rogue River valley are similar to central Oregon brushland species. For example, the magpie, sparrow hawk, Douglas ground squirrel, and black tailed jack rabbit are present. The Siskiyou Mountain salamander and sharp-tailed snake are classified as endangered by the State.

—Habitat Requirements. Wildlife are dependent on the great variety of transition zone hardwood trees and shrubs. Acorns provide food for tree and ground squirrels, certain woodpeckers, and wood ducks and are readily used by blacktailed deer in the fall and winter. Ceanothus, manzanita, scrub oak, and mountain mahogany are preferred browse species for wintering deer. The Pokegama - Jenny Creek area on the California border provides winter range for the largest migrating blacktailed deer herd in Oregon. Some mule deer are also found on the winter range.

This sub-biome can become very hot and a shortage of water can be a major limiting factor. Many small streams and ponds go dry during the summer. Some brushfields, especially those following wildfires, become too dense and stagnant to provide good wildlife habitat. Controlled

burning or cutting to provide basal regeneration, and escapement of understory grasses and forbs would be beneficial practices.

Continuing road development, power line rights-of-way, brush cutting for pasture development and sub-urbanization of southwestern Oregon is rapidly eliminating much of the former brushlands around the Rogue, Illinois, and Umpqua Valleys. With the loss of the brushland, many of the indigenous wildlife species lose their necessary habitat.

Palouse Prairie Grassland. This portion of the Palouse Prairie extends into the Rogue and Umpqua River valleys and is surrounded by the Broad Sclerophyll sub-biome. Most of the wildlife species in this portion of the grasslands range into the adjacent brushlands and are mainly identified with those species. In addition, the burrowing owl, marsh hawk, and California harvest mouse inhabit this area.

Some species found only in this sub-biome include the California meadow mouse, (Microtus californicus californicus) the northwest jumping mouse (Zapus trinotatus), Gabrielson's kangaroo rat (Dipodomys heermani gabrielsoni), and the Oregon brindled weasel (Mustela xanthogenys oregonensis).

Several species of waterfowl breed in and near this sub-biome. These include many common species such as the mallard and wood duck (Aix sponsa).

As with the northeastern Oregon Palouse Prairie Grassland, the grasslands of Rogue and Umpqua valley areas have been even more drastically reduced by intensive agricultural practices and housing developments. Human harassment is a major limiting factor to resident wildlife species. The California valley quail and the ringnecked pheasant were two species that had formerly adapted to the heavy human use of this sub-biome. At present, removal of winter and escape cover has substantially reduced their populations.

C. Ecological Interrelationships

All organisms share a common need to satisfy the requisites (food, shelter, moisture, respiratory gasses, etc.) for continuing life and reproducing kind. A vast array of interactions serves to meet these environmental dependencies. These interactions include relationships between the individual organism and organisms of the same and of different kinds, and between the organism and its non-living environment.

The General Abiotic Environment (non-living). Ecological interrelationships occur not in a vacuum but in physical-chemical settings of non-living or abiotic environmental components. These include basic chemical elements and compounds such as water and carbon dioxide, calcium and oxygen, carbonates and phosphates, and organic compounds which are the by-products of organism activity or death. There are also such physical

factors and gradients as moisture, winds, air currents, and solar radiation with its concomitants or light and heat. Within this abiotic environment, living organisms interact in a fundamentally energy-dependent fashion.

The General Biotic Community. Living organisms--plants, animals and microbes--form biotic communities which occupy a complex of environments. These organisms compete for the life-sustaining light, warmth, atmospheric gasses, water and nutrients provided by the abiotic environment. Each in its turn creates part of the environment affecting the others. These organisms are of two major kinds, autotrophic and heterotrophic. Autotrophic organisms are self-nourishing; heterotrophic organisms meet nutritional needs by feeding on other organisms. More specific classification is according to function, as follows.

Producers are autotrophic organisms which are able to manufacture food from simple inorganic substances. In this process, radiant energy (sunlight) is used to convert carbon dioxide, water, and nutrient minerals into carbohydrates that serve as food for the producer's own growth and metabolism. Producers are largely the green, chlorophyll-bearing plants; e.g., the trees of a forest, the grass of a field, the algae of a pond. Of less significance as producers are phyotosynthetic and chemosynthetic bacteria.

Consumers are heterotrophic organisms, chiefly animals, which ingest organic matter. A primary consumer (commonly an herbivore) derives its nutrition directly from plants; a secondary consumer, or carnivore, obtains its nutrition indirectly from the producer by feeding on the primary consumer. Included in the consumer class are mammals, birds, reptiles, fish, worms, parasitic fungi and certain bacteria.

Decomposers are heterotrophic organisms which reduce, or break down, complex organic compounds, absorb some of the products of decomposition, and release the remainder in simple forms usable by the producers. Bacteria and fungi are the chief decomposers, but such macro-organisms as millipedes, earthworms and mites also reduce complex organic compounds.

Ecosystems

A general abiotic environment and associated biota (a general biotic community) together comprise an ecological system, or ecosystem, in which living organisms and non-living matter interact to produce an exchange of materials between the living and non-living parts. An ecosystem, then, is a complex of vegetation, bacteria, fungi, protozoa, arthropods, various other invertebrates, vertebrates, oxygen, carbon dioxide, water, minerals, and dead organic matter. Such a complex is never completely in balance; an ecosystem is constantly changing diurnally, seasonally and with long term climatic cycles.

Resisting sudden, radical changes are checks and balances, forces and counterforces, which maintain a semblance of equilibrium between organisms and environment, thus tending to stabilize the ecosystem as a whole. These factors are known as homeostatic mechanisms. These include processes which regulate the storage and release of nutrients, the growth of organisms, and the production and decomposition of organic substances. As an example of the function of these mechanisms, consider the rate of photosynthesis of a whole biotic community. This may be much less variable than that of individual organisms or species within the community because, when one individual or species slows down its rate, another may accelerate in a compensatory manner. As another example, when treated sewage is discharged into a stream at a moderate rate, the aquatic ecosystem is able to purify itself by homeostatic processes and to restore its previous quality within a few miles downstream. These mechanisms are not yet fully understood, but their important role in maintaining a natural ecological balance is known and recognized.

While the abiotic environment controls the activities of organisms, the latter influence and control the abiotic environment in many ways. Changes in the physical and chemical nature of inert materials are constantly being effected by organisms which return new compounds and isotopes to the non-living environment. Such organic influence can be very strong and its products significant; e.g., plants build soils which are radically different from the original substrates.

When the environment changes as a result of actions of organisms that increase soil fertility, or because of decreased light intensity, climatic variation or any other modification, conditions may become more favorable for some organisms other than those already present. There may then be replacement of one species by another or of one biotic community by another, with more replacements following in later successon.

Radiant energy, in the form of sunlight, is the ultimate source of energy for any ecosystem. The flow of solar energy, and two vital cycles, are the fundamental processes which give life to an ecosystem. The dynamics of these processes are described in the following paragraphs.

— Energy Flow. Chlorophyll, the green coloring matter of plants, converts carbon dioxide and water, in the presence of sunlight, into carbohydrates, with oxygen as a by-product, by a process known as photosynthesis. In effect, photosynthesis transforms radiant energy into chemical energy which nourishes the producer plant. During the process, the green plant also incorporates into its protoplasm a variety of inorganic elements and compounds. As the plant is utilized by herbivores, its stored chemical energy (and nutrients) are transferred to the consumers. Likewise, there follows a transfer of energy (and nutrients) from herbivores to carnivores and eventually to the decomposers.

This energy flow is one-way and noncyclic because, at each transfer along the food chain, energy losses occur. Within each link of the chain,

beginning with the producer plant itself, some of the nutrient matter is used to build protoplasm while the stored energy in the remaining food serves as fuel for metabolism and movement. These activities convert the stored energy to heat, which is dissipated into the atmosphere and thus lost from the ecosystem. Life is sustained by continuing solar radiation with its influx of new energy.

——The Nutrient Cycle. The nutrients produced by the green plants via photosynthesis are primarily simple carbohydrates (glucose). Two minor groups of producers, the photosynthetic bacteria and the chemosynthetic bacteria, use methods other than the process used by green plants to create carbon compounds of nutrient value. Further chemical changes, which occur with successive utilization along the food chain, convert the simple products of synthesis into more complex carbohydrates, proteins, fats and other nutrients.

These foods continuously circulate throughout the ecosystem from environment to producer, from producer to consumer, from consumer to decomposer, and from decomposer back to the environment, where they are potentially available for recycling. Thus, nutrients remain in the ecosystem; they are not lost in the manner of energy.

As the decomposers satisfy their own needs for growth and metabolism, they concurrently perform an invaluable service to the ecosystem; this is the mineralization of organic matter. By their digestive activity, the decomposers release basic elements (nitrogen, phosphorus, potassium, calcium, etc.) to the environment for reuse by producers. These elements are stored in the soil until extracted by the roots of vegetation, sometimes with the aid of mycorrhizal fungi (consumers) associated with the roots thus completing the cycle. Elemental nitrogen released from organic compounds by decomposers may be transformed into nitrate (the nitrogen derivative most readily used by green plants) in the soil, and stored there, or it may be released into the air. Atmospheric nitrogen is continually returning to the nutrient cycle through the action of nitrogen-fixing bacteria, algae or natural electrification by lightning.

——The Hydrologic Cycle. The nutrient cycle is made possible only by the circulation of water from soil to roots of vegetation, to the atmosphere, and from the atmosphere back to the soil. Soil nutrients must be in an ionic state, in solution, to be absorbed by root systems; this requires the presence of soil moisture. Water also controls the rate of nutrient movement through the conductive tissue of plants, the decomposition of plant litter, and the development of the soil profile which, in turn, affects the availability of nutrients to plant roots as recycling begins.

A major feature of the hydrologic cycle is the interchange of moisture between the earth's surface and the atmosphere via precipitation and evaporation. Significant amounts of water are used by the biota of ecosystems, and there is a substantial return of moisture to the atmosphere by transpiration from living plants, as well as by evaporation. The relative and

absolute amounts of precipitation and evaporation significantly influence the structure and function of ecosystems.

In its broadest sense, the hydrologic cycle involves the oceans, continents, the fresh waters and the earth's atmosphere. At the level of the ecosystem, the cycling of water includes precipitation from the atmosphere, runoff in the form of streamflow, and a series of intermediate processes influencing the precipitation-runoff relationship. Among these are interception of precipitation by vegetative cover, infiltration and percolation of water through the soil, evapotranspiration from soil and vegetation, surface runoff and water storage at various levels of the system. While the nature of the biotic community is determined to a large extent by the hydrologic cycle, the biotic components are, in turn, a major influence on the cycle.

Ecological Variations

Different ecosystems may vary widely in productivity, one index of which is the amount of vegetation produced over a given period of time. The apparent mass of vegetation (the standing crop) may provide a good estimate of net productivity. Although biomass (the total weight of the biota, including stored food) is not a consistent measure of productivity, high rates of primary production are often associated with large biomass.

Variations in productivity from ecosystem to ecosystem are due primarily to differences in climate and soil. These factors control energy flow, nutrient cycling and water cycling, the vital processes by which the ecosystem lives. Generally, productivity is highest in ecosystems where abundant solar energy, ample precipitation and soils rich in nutrients promote rapid nutrient cycling and growth. The stability of the plant community is related to its productivity. Communities with low productivity are generally fragile, while highly productive communities generally recover rapidly from the impacts of heavy use or other disturbance.

Ecosystems may be conceived and studied as areas of various size. As long as a given area's major abiotic and biotic components exist and operate together with some sort of functional stability, even if only temporarily, the entity may be considered an ecosystem. On this basis, it is reasonable as well as convenient to consider the Oregon sub-biomes as individual ecosystems, with ecological variations from sub-biome to sub-biome, as follows:

Northwest Coastal Coniferous Forest (Sub-biome 1). This is, as a whole, the most productive of Oregon sub-biomes. The "standing crop" of producers at the lower elevation forest zones is impressive and future production potentially great, if harvest-regeneration and nutrient cycles can be maintained. Unlike the drier sub-biomes, understory vegetation in the lower elevational zones is well developed wherever light filters through

the forest canopy, while mosses and other moisture-loving plants are abundant.

Trees and lower levels of vegetation form a thick organic layer on the forest floor, to be broken down by bacteria and other decomposers. The ecosystem is complex; populations of producers, consumers and decomposers are relatively high. Removal of vegetation and other surface disturbance are generally followed by rapid replacement of biota through natural succession.

In general, influences of elevational differences within this sub-biome are less pronounced than in other sub-biomes due to the moderating effect of the Pacific Ocean.

Montane Coniferous Forest (Sub-biome 2). The distribution of biotic communities within this sub-biome is governed primarily by diverse physical conditions related to gradients in elevation and lesser oceanic influence. Mountainous areas are characterized by differential zonation of vegetation in irregular bands within various altitudinal limits, often with sudden transition from zone to zone.

As in the Northwest Coastal Coniferous Forest, the higher elevational zones are the least productive portions of the sub-biome because of short growing seasons. As a whole, the sub-biome is fairly productive despite its rather severe climate. The soil contains a moderate population of small organisms but comparatively few large ones. Consequently, the breakdown of organic material proceeds more slowly than decomposition in the Northwest Coastal Coniferous Forest. Generally, low precipitation during the growing season limits the energy-nutrient-water relationships of this ecosystem.

Broad Sclerophyll (Sub-biome 4). Despite the xeric conditions which prevail during the summer season, this ecosystem is capable of producing a considerable mass of vegetation annually. Its existence as an intermediate community between grassland and forest is favored by the occurrence of fire. Many of the species found in this plant community sprout readily from the roots after the tops are burned or cut, and regrowth is rapid. As with chaparral communities generally, most nutrient cycling and resulting vegetative growth take place in the spring season, when precipitation and soil moisture are high. Its productive capacity makes this sub-biome an important source of range forage for seasonal use.

Palouse Prairie Grassland (Sub-biome 3). This sub-biome occurs where growing season precipitation is too low to support forest or sclerophyll ecosystems but is higher than that which results in desert life forms. The inherent productivity of this ecosystem is quite high; in its original form, it must have been one of the most productive range forage regions west of the Rocky Mountains.

The factor limiting productivity is growing season moisture rather than nutrients. Growth occurs mainly during the early spring months, when frost-free temperatures coincide with ample soil moisture. Nutrient cycling and resultant production of vegetation are rapid during the spring growing season. Grasses are mature and dry by July 1, and remain dormant during the dry summer. Fall growth occurs only in unusually favorable years.

Over much of its original area, the natural vegetation of the prairie grassland has been replaced by brush and annuals which have invaded as a result of overgrazing. A large portion of the ecosystem has also been converted by cultivation to the production of agricultural crops.

D. Human Values

The Federal Government has been instructed to preserve the historical and cultural environment. Factors that shape or characterize the landscape can be altered by BLM practices. The objective here is to identify existing landscape types and the human values set therein so that BLM actions can consciously support a harmonious and qualitative environment.

Settlement

Although some early settlement had taken place in the southwest on Spanish land grants, it was only after the West became United States Territory, in 1846 and 1848, that the cross-country movement of pioneers gained momentum and the development of the West began.

Landform was the primary determinant of early settlement patterns. After crossing mountain saddles, the pioneers usually followed the rivers and valleys and spread out in the basins and plains. They preferred river banks and adjacent uplands for settlement. The rivers provided transportation and the trees growing nearby provided wood for home construction and fuel.

Settlement gained momentum when the vanguard of settlers reached the plains. Settlement and development of the public domain was further facilitated through passage of various public land laws. These laws were designed to provide title to tracts of land, varying in size from 160 to 640 acres, upon compliance with occupancy and use conditions.

Settlement, however, was only the initial step in development. Settlers who had located on the land could not remain isolated members of society. They were followed closely by churches and schools. Frontier towns and trading centers sprang up over the country. Travel to the West was greatly facilitated when, in 1869, the central transcontinental railroad was opened.

<u>Montane Coniferous Forest</u>. Although settlement and development took place readily in the more fertile valleys and plains, the establishment

of permanent settlements in the mountainous terrain that comprises the Montane sub-biome took place in a much different fashion. Characterized by steep, rugged topography with shallow, poorly developed soils, the mountains afforded little opportunity for homesteading. Exceptions occurred in sheltered fertile valleys between the ranges. Mining of gold and silver, and later timber harvesting, were the principal attractions of the western mountains.

The rugged western portion of the Cascade Range in the sub-biome is sparsely populated. The area is important as a supplier of water, timber, and other materials to the adjacent lowlands.

Communities tend to be small, and are economically oriented to logging, agriculture or ranching, mining, and more recently, tourism. A phenomenon that began after World War II and has increased alarmingly in some parts of the region having non-existent or weak local land use controls has been the development of "speculative" homesites. Frequently located in remote rural areas, these recreation sub-divisions more often than not have failed to develop as portrayed in the sales brochures. Large National Forests and parks in the area have virtually no permanent inhabitants.

Palouse Prairie Grassland. The area known as the Palouse Prairie Grassland sub-biome has a rugged surface which makes most of the land unfit for agriculture, but favorable for forest growth and excellent for recreation. Initially, mining for gold and silver was impetus for settlement. Although many of the early mining settlements have either disappeared or are ghost towns today, some more favorably situated have survived along with place names like "Gold Hill" to remind us of the gold rush years. In this area, mining still provides income and employment.

The Rogue River provides a scenic retreat for many visitors, and its valley is a fertile garden spot with irrigation encouraging the orchards of apples, pears, and nuts, and fields of grain, hay, and pasture.

Northwest Coastal Coniferous Forest. The history of early settlement of the coastal forest region followed essentially the same pattern as the Montane region to the east. Although rough and mountainous for the most part, the region contains some of the most productive softwood forests in the United States. Often referred to as the Douglas-fir Region for the principal tree species found there. Other valued softwoods are cedar, hemlock, spruce, and true firs.

The gold rush and subsequent population growth in California afforded the first export market for the region's vast supply of mature timber. This market expanded into the developing Midwest with the extension of intercontinental railroads into the Pacific Northwest in the 1880's and 1890's. Production of wood products for a national market was the single most significant economic factor contributing to the rapid population growth of the region into the 1920's.

The older alluvial fill of the Willamette and Tualatin Valleys provided rich soil for eager pioneer farmers. Soon agricultural products were finding their way downstream and overland to the City of Portland. Sited at the confluence of the Willamette and Columbia Rivers, the city became an important center of trade and transportation at an early date.

Farmers cleared valley land leaving extensive woodland only along stream courses; a frame of green for the many grain farms, dairy farms and orchards. The excellent farming country supported new population centers at Cottage Grove, Eugene, Corvallis, and Salem.

The forested Coast Range landscape consists of various forest types intermingled with cut-overs, burns, and cleared land. The area is lightly settled with individual farms of hay, fruit crops, or dairy pasture.

Population is concentrated along the level land of coastal terraces, and beside stream and river estuaries. Coastal lakes are an important source of water for coastal towns.

Oregon beaches provide miles of playground and scenic beauty for tourists and residents alike. The capes and headlands of the coast contribute to the character and grandeur to be appreciated.

The recreation-residential development industry has opened coastal territory to relatively concentrated occupation in the summer months. Older settlements occur at ports and estuaries where logging and fishing activities are the economic mainstay.

"In this region, then, one may say....that the inhabitants cut spruce and douglas fir for pulp and lumber, raise Jersey and Guernsey cows to make cheese, catch salmon and halibut for market and sport, and entertain tourists and themselves for profit and recreation. Any part of the physical region will probably include at least one of these activities, and thus be part of the cultural region." - John W. Gierhart

Economics

Although most of the forest lands within the Montane Coniferous Forest are inside National Forests, and are administered by the Forest Service, the BLM administers 1,631,000 acres of commercial forest on the public land within the region, from which $1,808,000 was received from sale of timber in 1971. *

* Excluded from these figures are the O&C lands administered by the BLM in Jackson and Josephine Counties in Oregon. Although they are within the Montane sub-biome, O&C land data pertaining to them are included with the other O&C Counties under the Coastal sub-biome section.

Lumbering and livestock grazing occur generally throughout the Montane sub-biome. Livestock grazing of the alpine meadows is normally limited to the summer months, with the animals being moved to lower ranges, outside the sub-biome, during the fall and winter.

Recreation-tourism is growing rapidly in importance throughout the sub-biome. The Pacific Crest Trail, routed along the crest of the Cascade Mountains, stretching from Canada to Mexico, leads to points of scenic beauty accessible only by pack horse or foot and annually receives increased use. Throughout the Montane region Federal, state, county, and municipal organizations as well as private enterprises have been active in the development of scenic and recreation resources. Hunting, fishing, sightseeing, picnicing and camping, and winter sports are the predominant types of recreation activities.

Lumbering and wood products industries continue to play an important role in the economy. In 1968 the Pacific Northwest Forest and Range Experiment Station estimated the degree of economic dependency upon timber industries of selected areas within the Douglas-fir Region of Washington, Oregon and California. Dependency was measured as a percent of total economic (or export) base employment attributable to timber dependent industries. The researchers found that timber dependent industries accounted for approximately 45 percent of the region's economic base employment. Table 6 shows timber-dependency ratings for 15 economic areas within the region.

Table 6 - Classification of Economic Areas by Degree of Dependency Upon Timber-Based Employment

Dependency	Economic Area*	Percentage of 1960 excess employment dependent on timber-based employment
Slight	Portland	23.8
	Salem	29.3
Moderate	Astoria	63.1
High	Medford	70.0
	Corvallis	74.3
	Eugene	76.6
	Coos Bay	91.6
	Roseburg	99.4

* Economic areas are identified by the names of their respective growth centers.

Note: The authors used the excess-employment technique to determine the portion of employment in an area which was engaged in economic base activities. This approach considers any industry in an area with employment in excess of the national norm for distribution of employment among industries to be producing for export. The percentage of total excess (export) employment (the total may include several industries, basic as well as service, for an area) attributable to timber related industries is computed and defined as the timber-dependency indicator (figures in the right-hand column of Table 6).

The Northwest Coastal Coniferous sub-biome of western Oregon, Washington and northwestern California contains over 2.5 million acres of commercial forest administered by the Bureau of Land Management. Comprised of both the O&C and public domain, these lands are generally recognized as one of the nation's most productive and valuable commercial forest properties. During 1971 approximately 1.23 billion board feet of timber worth $52 million were sold from 1.9 million acres of O&C land in Oregon. From this $31.8 million were distributed to the 18 O&C counties under terms of the O&C Act of 1937 and subsequent agreements.* Receipts for Fiscal Year 1972 on a volume of 1.19 billion board feet were $65.5 million of which $37.7 million were distributed to the counties (receipts to the counties include revenues from sale of timber from O&C lands (the largest source), grazing fees, mineral fees, rental and sales of land, and from other sources).

The O&C lands contribute 17.5 percent of the timber harvest in western Oregon. In this same area timber-dependent industries account for 45 percent of the total economic base employment. This dependency ranges from a low of 24 percent in the Portland area to 99 percent in the Roseburg area (Table 6). Thus the O&C lands contribute approximately 8 percent of the total western Oregon economic base employment. The significance of these lands to local and regional economies is further exemplified by the fact that 17 percent (13,500) of the 78,000 persons employed in the lumber and wood products industry in western Oregon in 1965 could attribute their jobs to the O&C timber cut. Payrolls were $89.5 million and the value added to the economy, including the value of the timber cut, was $187.1 million. This compares with the value of total products sold on farms of the 18 counties of $245 million. It is greater than the value added by any other Oregon industry, with the exception of the total lumber and wood products industry.

* Although Jackson and Josephine Counties are within the Montane Forest sub-biome, for purposes of clarity O&C data from them are lumped with the O&C counties in the Coastal sub-biome.

These jobs in the basic industry in turn generated more than 20,000 other secondary employment jobs (retail, service, and other employees serving the basic employees), and supported a total population of about 80,000 (including the employees and their families).

The Pacific Coast forms the western boundary of the Coastal sub-biome. The proximity to the ocean adds to the recreational diversity of the area. Outdoor activities such as swimming, fishing and camping are some of the more common forms of recreation activity. Digging of clams, both commercially and as a form of recreation, takes place on the beaches and inlets all along the coast. Fishing the numerous streams that traverse the coastal strip, many on BLM administered lands including such nationally known ones as the Rogue and Umpqua, yield exciting fresh-water catches. Saltwater sportfishing has created and supports a growing charter boat industry.

Most of BLM administered land in the Coastal sub-biome is available to the public for hunting. Since much of the area is covered by a dense forest, most of the hunting is concentrated in natural or man-made openings such as roads, timber harvest sites or cleared utility rights-of-way. Livestock grazing also occurs in localized areas on the lower, more open sites administered by the Bureau.

Aesthetics

The Montane Coniferous Forest and the Northwest Coastal Coniferous Forest, provide some of the most spectacular scenery in the western United States. Natural attractions located throughout the Montane region annually draw hundred of thousands of sightseers. The rainforests of the Douglas-fir region of western Oregon offer a more or less continuous panorama of towering forest broken by occasional streams tumbling from the Coast Range Mountains to the Pacific Ocean. Less apparent from the ground except in localized areas, man's intrusion into the coastal forest with roads, power transmission corridors and timber harvest activities create harsh contrasts when viewed from the air.

Land forms vary from the rounded foothills of the Cascades and Coastal Range to angular peaks, from relatively flat valleys to nearly vertical canyons. Natural lines occur more often in the environment of the Montane than in the Coastal sub-biome. These may occur as abrupt changes in vegetation types caused by soil changes or rock intrusions. They may occur as horizontal deposition lines on the face of an exposed cliff or cut bank.

Scale is frequently so vast as to be overpowering to those more accustomed to urban surroundings. The extreme vertical relief common to the mountains is frightening to some. To others the solitude of the mountains and the remoteness offer a welcome contrast. The wide variety of forms, textures, colors and natural lines are what make the scenic values interesting, while vastness of scale and distance bring feelings of isolation and solitude to those who live within or visit this region.

Geology

The Montane contains geologically interesting features left by glaciation. Included are morains, lakes, U-shaped valleys; erosion features like canyons, pinnacle peaks and mudlows; volcanic features such as lava flows, eroded ash beds, calderas, hot springs and geysers.

The Northwest Coastal is edged with an interesting eroded coastline of natural arches, isolated rock islands, sand dunes and steep cliffs. The higher elevations contain canyons, volcanic features, caves and faulting evidence.

Archeology

Early man's entry into the New World from Asia via a Bering Strait land bridge, estimated to be 1000 miles wide when the seas were at their lowest, is believed to have occurred between 20 and 40 thousand years ago. Radio-carbon dated remains going back to about 10,000 B.C. show well-developed stone-chipping techniques and hunting skills adapted to the taking of large animals. Most evidence comes from game kill sites and stratified cave deposits.

The Northwest Coastal Coniferous Forest was the home of the Northwest Coast culture. Essentially a river or river-mouth culture, oriented around salmon fishing, the Northwest Coast culture is noteworthy for its vigorous and distinctive art and great use of wood. Village sites were located along streams and near sheltered inlets along the coast that may attract a suspected site.

Any specific BLM project should be preceded by a preliminary archeological survey. An evaluation of the findings would determine whether the site was of value and whether it should be salvaged by removal, or left and circumvented by the project. For specific information, contact: The Museum of Natural History, University of Oregon, Eugene, Oregon.

History

Scattered throughout the Coastal Forest are remainders of the region's early history. Old mining and logging camps, remnants of military posts, and preserved homes of early pioneers are some examples. For instance, Champoeg, near Newberg, was the site of the vote establishing a provisional government in Oregon until Congress would extend its jurisdiction. This was the first American government to be established west of Iowa. Today Champoeg is a State park.

BLM projects possibly affecting areas of historical value should be preceded by a search through the cultural and historical site listings currently on file with and soon to be published by the State Parks Department. For specific information, contact: Mr. Paul Hartwig, State Parks Department, State Highway Building, Salem, Oregon 97310.

III. ANALYSIS OF PROPOSED ACTION

Usually, an environmental analysis record must analyze both the proposed action and its alternatives. However, as previously explained in Section I.A., in this instance the State Director has no major alternatives to consider since, at the policy making level, it has been decided to proceed with the proposed action as described. Major alternatives to the proposed action are analyzed in the Bureau-wide programmatic environmental impact statement for timber management.

Thus, the following section analyzes only the effects of the various means which may be employed to execute the proposed action. This range of methodology represents the real "alternatives" which must be considered at the operations level. Documentation of the rationale for selection of certain measures and practices for a specific proposed action will be found in the EAR for that particular action.

At this point in the analysis, BLM directives call for a description of the "normal procedure" for accomplishing the action so that the subsequent discussion of impacts could concentrate only on those that would occur under the "normal" practice.

Because of the infinite variability of the micro-sites to which timber management practices are applied, it is impossible to describe a meaningful "normal procedure". Thus, the following section entitled Anticipated Impacts will attempt to list all impacts reasonably expected as a result of each management practice.

In using this document to analyze the impacts of a specific action occurring in a specific location, the reader will have to refer to the case file (e.g., timber sale contract, reforestation specifications, road construction stipulations, etc.) to ascertain which of the potential impacts associated with a management practice are not likely to occur because of managerially imposed constraints. The reader can then concentrate on following through on the remaining possible impacts.

To illustrate, a potential impact of tractor logging is the fact that soils are compacted if tractors are used when soils are wet. An individual timber sale may call for tractor logging, but it may contain stipulations that, because of the particular soil type involved, tractor logging can be carried on without the compaction hazard if conducted when the soil moisture content is below 30 percent. When the soil moisture is above 30 percent, tractor logging will not be allowed.

Thus, it is important that the reader first determine which of the possible impacts has been eliminated by management constraint, and then use the list of possible impacts in this section as a catalog to see which impacts still remain as possibilities.

An aspect not covered by this document is the cumulative magnitude of the many, relatively small actions that in total comprise the timber management program. Such items of information such as the total number of acres clearcut per year, total areas reforested or thinned, roads built per year are not included here. For this information the reader is referred to two publications; namely, "Public Land Statistics", published annually by the U. S. Government Printing Office, and "BLM Facts" published annually by the Oregon State Office of the BLM.

An environmental analysis worksheet based on BLM Manual 1791 is included. This worksheet was used as a guide to analyze the impact of individual practices for each sub-biome, i.e., Northwest Coastal, and Montane Coniferous Forests. However, with some exceptions, the impacts and their magnitude were relatively the same for the two sub-biomes. Thus, to avoid a great deal of redundancy, the impacts (for each component of the environment) common to the total Coniferous Forest Biome are presented and, when applicable, augmented by the impacts that are unique to a sub-biome.

A. Anticipated Impacts

Air

Forest regions are products of the general climate of the earth, over which man has no real control. However, to the extent that man can destroy or conserve forests, he does control some local climatic factors. Viewed in this light, the forests of the Coniferous Forest Biome assume much greater social significance than they would have if thought of solely as an economic resource.

The climate in which a given tree or stand lives may be entirely different from the regional macro-climate. In recent years, much has been learned about the micro-climate--the climate near the ground, surrounding the tree. Man's activities can alter the micro-climate.

Some of the proposed actions will have significant but relatively local effects on climate and on air quality and movement. These local effects may cause climatic reactions upon the forest ecosystem.

Development. Area burning and spot burning, like wildfire, create smoke, which is regarded in varying degrees as an air pollutant. Much of the organic matter in smoke from forest fuels is similar to material naturally entering the atmosphere from living vegetation or from the decomposition of vegetative material. Research indicates that toxic compounds released into the air by burning forest fuels are negligible. There is no evidence that the combustion products of slash burning cause permanent injury to human health. The corollary conclusion is that area burning and spot burning have no significant adverse impact upon air quality. Area burning can modify or change the micro-climate. Its impacts can be adverse or beneficial.

An area burn after clearcutting can consume both the organic duff and the slash and brush which still provide some shade for the forest floor, thus exposing the mineral soil to direct solar radiation. In some ecosystems, the resulting climatic reaction may produce a well-stocked stand of Douglas-fir seedlings. In others, lethal soil surface temperatures or deficient moisture may inhibit the establishment of tree seedlings and favor invasion by brush. At the lower edge of the Coniferous Forest Zone, fire may so modify the local climate through destruction of cover and exposure of surface soil that plant succession may end with colonization by grasses or shrubs characteristic of the next lower vegetational zone. At the higher elevations well within the coniferous forest, succession after fire will normally lead to eventual replacement of the coniferous forest itself.

Chemical and mechanical removal of brush can modify the micro-climate by increasing the amount of solar radiation reaching the forest floor and by reducing soil moisture losses from vegetative transpiration. The resulting increases in soil temperature and available moisture may favor natural or artificial reforestation, or improve the growth rate of established crop trees by releasing them from competition with brush for light, moisture and soil nutrients.

However, brush removal can have adverse effects on the micro-climate in terms of tree growth. Research has shown that brush can have a beneficial role. Brush cover may increase seedling survival and provide more favorable soil moisture and temperature relations than open areas.

Reforestation and afforestation by seeding and planting alter the micro-climate gradually, until crown closure is achieved and the forest canopy is continuous. Significant changes will occur:

- The mean maximum monthly air temperature in the forest will be several degrees lower than it was in the open.

- Forest soil temperatures will be slightly warmer in winter and 5° F. to 9° cooler in summer than in the open and freezing of forest soil, if any, will be less deep than in the open.

- Solar intensity will be greatly reduced.

- Relative humidity of the air within the forest will be 3 to 12 percent greater than in the open, and evaporation of moisture from the forest floor will be much less than from soil surfaces in the open.

- Wind velocities within the forest will be much lower than those in the open.

Precommercial thinning increases the intensity of sunlight within the young stand, increases air and soil temperatures and makes more soil moisture available for use by the residual trees.

Protection. Backfiring can affect the local forest climate. The effect of a light burn, confined to the forest floor, might be insignificant. A hot backfire, particularly a crown fire, can kill all vegetation, consume the organic material on the forest floor, and have the impacts on micro-climate described under area burning in the preceding subsections.

Cutting Practices. Depending upon the extent to which they open the forest canopy, all cutting practices affect the micro-climate. The impact may be insignificant (light selection cutting), moderate (intermediate shelterwood cutting or commercial thinning) or great (extensive clearcutting). To varying degrees, each type of cutting increases solar intensity, air and soil temperatures, surface evaporation, and air movement and wind velocity; and decreases vegetative transpiration and relative humidity.

Climatic reactions upon the forest ecosystem are variable. Increased sunlight stimulates the sprouting and growth of branches on stems of trees; higher soil temperatures and more available soil moisture may accelerate tree growth; increased wind velocities may cause windthrow of reserved trees in a partially cut area or along the edge of a clearcutting. The altered micro-climate may favor or inhibit forest regeneration.

Logging Methods. There may be short term emissions of pollutants from the engines of machines, and dust from yarding operations, which affect air quality slightly.

Transportation. Right-of-way clearing for forest roads has impacts upon the local climate which are similar to those of clearcutting. Several of the road construction activities can cause temporary degradation of air quality by emission of engine exhaust fumes and particulate matter. Dust from construction operations may be locally heavy; its effect may be accentuated by increased movement of air and higher wind velocities in the corridors created by right-of-way clearing. Transportation of logs by truck can degrade air quality along a forest road. During dry weather, trucks operating on unsurfaced roads or on gravel surfaces may raise heavy clouds of dust. On heavily used mainline roads, dust may be noticeable for long periods each day.

Land

Development. Scarification disturbs the protective litter layer and churns up the topsoil. These actions expose the topsoil to raindrop splash erosion and subsequent soil creep. Compaction of the soil, which reduces productivity, will result if scarification is done during periods of soil wetness.

Mechanical brush cutting will result in soil compaction from the equipment when the soils are wet, however, the cut brush will add to the soil cover and hasten the natural nutrient cycling in the soil.

Mechanical trenching-furrowing will expose the soil to erosive elements in the trench. It will slow down erosion from overland flow if the trench or furrow is contoured and wide enough to effectively divide the slope into shorter segments. However a wide sloping trench or furrow will also act like a road for erosion, mass wasting, and loss of productivity.

Area burning causes a loss in plant nutrients from the soil nutrient cycle. Organic matter, nitrogen, sulfur, and about 30 percent of the phosphorous are lost during burning. There is a short term accelerated growth burst but it is accompanied by a long term loss of productivity. Burning the organic matter also creates a hydrophobic soil surface condition, especially under dry conditions on coarse textured soils. This hydrophobic condition causes surface water runoff, hence erosion.

Spot burning intensifies the conditions outlined under area burning, sometimes to the point of soil sterility which lasts for a number of years.

Burying slash causes soils to be exposed to erosive agents when the litter is removed. The wasted soil will also ravel or creep downhill if a steep slope gradient is involved. Chipping slash and spreading it back over the land will give additional litter cover, causing a temporary reduction in available soil nitrogen, and hasten the natural nutrient cycle. Chipper equipment will cause soil compaction. Seeding and planting will protect the soils from erosion. Mechanical planting will cause some compaction and expose soil for erosion for a short time. Mulching the soil surface protects it from erosion. It will cause a suppression of natural growth which provides a natural watershed cover. Fertilization with the proper amounts of nutrients will not harm the soil. It will promote additional vegetative growth which in turn provides better cover against soil erosion. Precommercial thinning and pruning results in organic materials which fall on the forest floor causing a temporary suppression of available soil nitrogen as they decompose. Gas or chemical spills could cause temporary soil sterility.

Protection. The use of insecticides and fungicides can cause an imbalance of soil macro-fauna and fungi for an unknown period of time. The full impact of this shift in population balance is not known. The degree of the shift would depend upon the quantity applied, depth of penetration and length of time before decomposition. These factors are quite variable depending upon rate of application, types of chemicals used, and climate. The use of retardants to suppress fires is not detrimental unless there is a high proportion of a micro element such as boron. Tractor constructed fire lines expose the soil to erosion forces. Lines running up and down the slope expose the soil to conditions which cause serious erosion. Materials cast aside into draws can increase the potential for mass wasting. The impact of backfiring is similar to area burning described under Forest Development.

Cutting Practices. As a result of any cutting practice organic material will be added to the forest floor more quickly than it would be naturally, barring catastrophic windstorms, etc. There will be a temporary reduction of soil nitrogen for plant growth because of this addition. The added material will also build up the forest floor, hence more protection from raindrop erosion. Clearcutting and seed tree cuttings expose more of the soil to erosion forces than the other cutting practices. Usually the heaviest cuts give the most soil disturbance. Landslide potential on non-cohesive soils increases with time on clear-cut and seed tree areas which occur on 80%+ slopes.

Logging Methods. The unmitigated effects of logging methods upon the soil are interrelated functions of types of soils, equipment, weather, and topography. For example, a soil may be severely damaged by crawler tractor logging during times of soil wetness. But the same soils may not be harmed if the same operation is conducted when the soil is frozen and protected by snow cover. The hazard of soil sterilization in small areas from fuel or oil dumping and spills is always present when motorized equipment is employed.

Those logging systems which generally have only a slight impact upon the soil are skylines, balloons, and helicopters. These systems require the least amount of roads and trails and cause the least amount of litter and surface soil disturbance. Impacts include road and landing construction, which initiates soil erosion and sometimes landslides. Small areas around landings and ridge tops, etc., will have the protective litter layer scraped aside exposing the soil to erosive forces.

Logging methods which generally have moderate impact upon the soil are horse skidding, high-lead yarding, and mobile yarder-loader operations. These methods require more roads and landings than methods listed in the above paragraph. They also disturb a larger percentage of the litter layer and topsoil. Trails where the logs are skidded become scraped and compacted. These two conditions concentrate water and provide areas for overland flow of water which can lead to rill and gully erosion.

Logging methods which generally have a severe impact upon the soil are the crawler tractor or rubber tired skidder and jammer yarding. Tractor logging disturbs and compacts as much as 40 percent of the area. The main skid roads receive the severest damage and occupy about 20 percent of the area. Soil structure is usually destroyed on frequently traversed areas and is more easily destroyed if the soils are wet. Surface runoff is the rule under these conditions. Tractor logging causes deep soil disturbance over 15 percent of the area while moving cable logging causes 1.9 percent. Tractor logging causes 5.9 percent shallow soil disturbance over the area while cable logging causes 13.3 percent. Jammer yarding requires a dense road network. Many more areas are removed from the timber production base as well as exposed to erosive forces by utilizing jammer yarding rather than logging methods listed as having slight and moderate impacts.

Transportation. Construction site operations create erosion and sedimentation problems mainly during the relatively brief period between land clearing, shaping, and stabilization of the new soil surface. The released sediment may have a lasting effect on the channel shape of a stream as well as affecting the construction project and water environment downstream. The impact of construction operations upon the soil are interrelated functions of types of soils, equipment, weather, and topography.

Clearing and grubbing opens up an area and removes the vegetation and disturbs and exposes the soil to erosive elements. It can cause soil compaction, particularly on wet soils, accelerated erosion and disrupts the nutrient cycle.

The excavation of earth or rock from its natural resting place has several impacts on the soil resource. It alters the natural drainage from hillsides and exposes underlying soils to weathering action. It removes lateral support to adjacent material. On hillside cuts it may unload a slope at a critical point and trigger landslides. Roadside cut slopes are bare, erodible watersheds which can increase sediment and drainage problems. Blasting in rock excavation compacts, shakes and fractures the soil resource. Topsoil may be poorly disposed of or wasted.

Embankments consisting of man-made deposits of soil, constructed of filled-in materials, may affect the soil resource by a combination of equipment and soil placement operations, particularly during wet weather. Fills add weight to the underlying soil mass, which on steep hillsides can trigger landslides or slip failures. Added weight of fills on faulty foundations can result in slumps and settlements. Newly constructed fills have bare slopes which contribute to erosion and sediment until stabilized. Fills placed at a greater angle than the normal angle of repose are prone to failures.

Grading operations impact soils by cutting, smoothing and disturbing surface materials on the road surface, fill slopes, cut slopes, ditches and other areas requiring shaping. Wet weather during these operations can cause erosion and sedimentation.

Seeding and mulching equipment used in stabilization efforts during wet soil conditions may rut and disturb the areas they are traveling over causing erosion and sedimentation problems. Time of seeding operations may result in lack of seed germination; thereby leaving bare slopes exposed to soil erosion. Topsoiling and seed bed preparation by tillage and discing loosens and disturbs the soil so that it may be easily eroded prior to turf establishment. Shoulders, fill slopes, slopes of ditches, drainageways, areas around drainage structures, cut slopes, other areas outside the rounded tops of cuts and toes of fills are possible erosion generators.

Quarrying operations require the opening of a rock source, removal of overburden, and excavation or mining of the rock materials needed for construction purposes. Quarrying impacts the soil resource by changing the land use, by removal of material and by exposing underlying materials to weathering. Explosives used in this material removal operation fracture, shake and disturb the soil resource. The loosened soil and overburden material are ready sources of soil erosion.

Bases distribute the load to the underlying soils and surfaces provide a wearing surface and prevent infiltration of water into the base. The impervious surface material creates a watershed which impacts the exposed shoulders and fill slopes and causes soil erosion and sedimentation of streams. The transmitting of load to the foundation by the base may result in deformation or settlement. Use of excessive oil application on an area and oil spillage during filling operations may contaminate soil and water.

Carrying large amounts of water for long distances in roadside ditches particularly on steep gradient may cause ditch and fill slope erosion. This detrimental erosion may result in the destruction of productive soils, the clogging of ditches and drainage structures endanger the stability of side slopes in embankments and cut sections. Accelerated erosion of ditches may be caused by excessive water velocities and easily eroded soils.

Construction of bridge structures and across road drainage structures can affect stream sedimentation through equipment disturbing the streambed and streambanks and by pushing loose material (logs, branches, and soil) into the stream during site preparation and construction. Approach fills, banks, bedding and backfill material can be ready sources of soil erosion material. Bridges and culverts may constrict natural waterways, thereby increasing the velocity of water which may cause scour and soil erosion. Culverts not properly oriented with natural stream channels and without proper inlet protection, gradient, outlet control or proper outlet discharge may cause bank erosion and scour holes at culvert outlets, resulting in soil erosion and stream sedimentation.

Under maintenance surface repairs of dirt, gravel and bituminous surfaces contribute to sedimentation and soil erosion by material loss, improper drainage, pot holing, stripping, rutting surface irregularities, and by dust loss. Spillage of petroleum products or excess application may result in soil contamination. Materials removed from plugged culverts and ditches may contribute to soil erosion and sediment problems. These waste materials may erode or creep if placed in unstable locations.

Equipment working in the stream to repair structures causes disturbance of the streambed and banks. Moving materials in flowing water to repair banks, piers, abutements and approach fills causes soil erosion and stream sedimentation.

Debris and slide removal practices impact the soil resource by the method of removal (sidecast or removal to designated waste areas) and

the location (stable or unstable) in which these materials are placed. Improper actions in removal and in relocating these materials makes them prime sources of material for soil erosion and stream sedimentation. Waste soil may ravel or creep downhill if steep slope gradients are involved.

Chemical brush control is not usually detrimental to the soil. Mechanical brush cutting adds to the soil cover and speeds up the natural nutrient cycling in the soil. The equipment used can cause some soil compaction and disturbance action.

Water

Development. Area burning can affect the quality of surface water. Hot slash fires that expose mineral soil to precipitation can result in surface erosion or mass wasting which, in turn, may cause sedimentation of forest streams. Severe burning can significantly increase sediment yields. The effect is emphasized on steep slopes in areas of heavy precipitation.

Sediment concentrations after hard burning may be many times greater than those observed on an undisturbed watershed. These abnormal sediment yields may persist for several years after burning, steadily declining as the exposed mineral soil becomes revegetated. Nitrate concentrations in stream water may increase following burning. Observations made so far would indicate that these concentrations will be far less than the limit of 10 parts per million recommended for domestic use, and well below any level deemed harmful to aquatic life. However, on one study area, a surge of nutrients in streams, following area burning, contained concentrations of ammonia and manganese that exceeded Federal water quality standards for a period of 12 days.

Area burning can also cause significant increases in stream temperatures. Even if all merchantable timber is removed by clearcutting, the resulting slash and uncut cull trees and brush may provide enough shade to maintain maximum water temperatures at levels only slightly above those which prevailed before logging. The amount of temperature increase is highly dependent upon groundwater inflow, topographic shading, stream width, depth and velocity of flow, in addition to streamside shading. Hot slash fires reduce or eliminate this streamside shade, with resulting exposure to direct solar radiation which can cause increases of at least 14° F. in mean-monthly maximum stream temperatures. These temperature increases may be critical to the aquatic ecosystem and survival of the life it supports.

The effects of area burning on ground water are less well documented. However, it is known that high fire temperatures at the soil surface reduce water infiltration rates by producing a non-wettable (water-resistant) layer of soil beneath the ash-dust surface and the mineral soil immediately

under the surface. The water-repellent layer lies parallel to the soil surface, and may vary in thickness from 2 to 4 inches. The presence of this barrier means that only a thin surface soil layer is available to store and transmit water during a rainstorm. Consequently, even in relatively light showers, the surface layer quickly becomes saturated, producing excessive surface runoff and erosion and, of course, stream sedimentation. Although no known research has been conducted on the effects of such reduced infiltration, it seems logical that, if the impermeable layer is extensive in area, the groundwater table could be significantly affected.

The indiscriminate use of heavy equipment in scarification can cause sedimentation and turbidity of lakes and streams. The magnitude of this water quality degradation will vary directly with slope, amount of precipitation, instability of the soil mantle, and area and depth of soil disturbance.

The use of chemicals in baiting, treated seed, animal repellents, and weed control also has potential for significant degradation of water quality. Knowledge is lacking regarding the long-range effects of these substances on our water resources. The biological significance of trace amounts of many of the complex carbon compounds is only partially understood, their persistance in natural waters largely unknown.

The use of toxicant and repellent chemicals to protect seedlings from rodents and browsing mammals is limited to ground applications in forest nurseries and seed orchards. Under these controlled conditions, these chemicals pose no threat to water quality. However, aerial application of the chemical sprays is used in weed and brush control.

In these operations, the possible entry routes of chemicals into surface waters may not be recognized. Large amounts of herbicides may enter water in a short time when streams and lakes are included in treatment areas. Significant amounts of aerially-applied herbicides may not reach the target area intended for treatment because of lateral drift due to air movement or interception by the forest canopy. Studies have shown that only small amounts of intercepted herbicide will enter the aquatic environment due to the washing action on the forest canopy. Likewise, subsurface flow or leaching of herbicides through the soil profile to groundwater and finally to surface waters is a slow process capable of moving only small amounts of chemical relatively short distances. This finding indicates that the impact of herbicides on the quality of groundwater is slight.

However, surface flow or runoff can move large amounts of chemical a long distance in a short time. Chemicals moving in surface flow need not be in solution but may be adsorbed on soil particles. Sheet erosion of soil from areas treated with herbicides is a serious threat to the quality of the aquatic environment. Steep slopes, reduced ground cover, and

compacted soils encourage surface flow of water and movement of herbicide residues.

Research experience indicates that concentrations of herbicides exceeding 0.1 ppm will seldom be encountered in waters adjacent to carefully controlled forest spray operations. These concentrations are well within limits considered acceptable. Concentrations exceeding 1 ppm have never been observed and are not expected to occur, although there remains the possibility of accidental spills. The chronic entry of the usual herbicides into streams for long periods after application does not occur.

There remains for consideration the possibility of contamination of water by diesel oil, one of the principal carrying agents used with forest herbicides. A comprehensive review of pertinent research literature has indicated that petroleum carriers, carefully applied, present no significant threat to the quality of surface water or groundwater. One researcher found that most danger lies in careless handling of oil containers and unused oil, and in field cleaning of spray equipment.

Forest fertilization involves the aerial distribution of chemicals to promote tree growth. The nitrogen is usually applied as large, specially coated urea granules (forest prills). These granules are relatively heavy and have eliminated the problems of lateral drift and foliar interception experienced in the aerial application of herbicides. Thus, control of nitrogen application is relatively good; nearly all of the fertilizer reaches the target area.

The greatest potential route of fertilizer nitrogen entry into the aquatic ecosystem is by direct application to exposed surface water in the area treated. Overland flow is also a major factor in areas where surface runoff commonly occurs. Subsurface drainage of dissolved nitrogen also moves the fertilizer into streams.

Despite the filtering effects of forest soils, measurable levels of nitrogen compounds have been found in streams monitored for water quality. In several studies of the effects of forest fertilization on water quality, maximum standards set by the U. S. Public Health Service were not closely approached, even during the short-lived peak concentrations. While testing of the effects of fertilization on forest waters has revealed no serious adverse impacts to date, knowledge in this area of research is incomplete.

Protection. The use of chemicals in forest protection involves applications of insecticides, fungicides and fire retardants. Fungicides are applied in seed orchards by readily controlled ground methods, without hazard of damage to water resources. Insecticides applied by aerial methods can enter forest waters by the same routes followed by the herbicides used in development treatments. The principal routes of entry are direct application or drift of spray materials to the water surface, and overland flow of insecticides in surface runoff.

Conditions favoring the contamination of the aquatic ecosystem by insecticides are the same as those which favor the entry of herbicides. However, insecticides in general are less mobile in soil than herbicides.

The toxicity and persistence of chemicals used as forest insecticides is variable. The chlorinated hydrocarbons (DDT, dieldrin, chlordane, etc.) are not usually toxic to mammals in the concentrations normally encountered, but fish and aquatic organisms may be highly susceptible. These compounds are especially resistant to degradation to non-toxic end products, and may persist in soil for months or years following application. Most of them are only slightly soluble in water. Daily ingestion of sub-lethal doses of DDT may be accumulative and fatal to mammals. Its extremely adverse effect upon the reproduction of birds is well known. The organophosphorus insecticides (parathion, malathion, etc.) are highly variable to toxicity to different species of similar organisms. Parathion can be highly toxic to mammals, with noticeable effects on humans possible from a water supply contaminated by spray treatment. The toxicity of malathion to warm-blooded animals is estimated to be only about 1 percent that of parathion. The residues of some of these compounds disappear quickly, but the persistence of dangerous amounts of parathion in soil has been documented. Pyrethrum does not appear to be significantly toxic to most life forms. It does not persist in the environment and the possibility of its movement from soil to streams is slight.

Several chemical fire retardants containing ammonium or phosphate compounds are widely used to suppress and control forest fires. Some retardants are applied by ground units or helicopters, by which maximum control and utilization on the target area can be achieved. Aerially applied retardants may enter waterways or lakes directly or by movement in surface runoff.

The major known effect of these chemicals on the environment appears to be their impact on water quality and on fish and other aquatic life. There have been some documented kills of fish caused by field applications of retardants. Laboratory tests have established that four commonly-used retardants are toxic to juvenile salmonids, spiny ray fish and common aquatic organisms at concentrations which could occur in natural waters as a result of field applications. Those retardants with higher percentages of potential ammonia appear to have the more lethal effects on fish; the phosphate-based retardants seem to be less lethal.

Although research so far completed has focused on the effects of retardant chemicals on fish, it is probable that they also have significant impacts on the quality of water for domestic use and watering of livestock and terrestrial wildlife. The colloidal material (clays, etc.) used as carriers with these compounds are chemically harmless but could cause turbidity in surface waters.

Fire line construction can cause sedimentation and turbidity of surface water by the exposure of the mineral soil to the impact of rainfall

and surface runoff resulting in erosion and soil movement into streams and lakes. The effect increases with slope, amount of precipitation, instability of the soil mantle, and area of surface disturbance. Building fire line by tractor disturbs much more surface area than does line building by hand-trailing, and is thus more destructive under comparable conditions.

Cutting Practices. Only unmodified clearcuttings, and to a lesser extent some seed-tree cuttings, cause removal of forest cover which exposes natural water surfaces to continuous, direct solar radiation. Under a continuous forest canopy, sunlight reaching stream channels is largely diffuse and intermittent, and changes in water temperature vary primarily with air temperature. When the forest cover is removed, direct solar radiation provides much of the energy required to raise water temperature.

The effect on water temperature is most pronounced when clearcutting is followed by area burning of slash, which is common practice. The slash and brush remaining after removal of timber may provide shade which may maintain water temperatures at relatively low levels. Elimination of this shade by burning exposes the water surface to direct solar radiation. An increase in maximum stream temperatures from about 57° F. before clear-cutting and burning to about 85° afterward has been observed. Increases in water temperature favor the growth of pathogens and reduce the supply of dissolved oxygen, with adverse effects on aquatic life. Water temperature increases can also cause fish mortality.

Clearcutting by itself may not cause sedimentation of natural waters. Clearcutting alone, using moving-cable systems, seldom produces significant surface erosion. In many situations, erosion and sedimentation occur only when clearcutting is followed by a hot slash burn. These effects are discussed under area burning.

However, there are other problems associated with clearcutting on steep slopes in areas of heavy precipitation. Under these conditions, clearcutting may be followed, after several years, by mass soil movement downslope, resulting in sedimentation and degradation of water quality. This delayed impact is caused by deterioration of the root systems of the trees removed.

Considerable logging debris may be deposited in natural waters as a result of clearcutting. This organic material contains simple sugars which are released by leaching and used as food by aquatic micro-organisms. In the process, these organisms extract much oxygen, thus reducing the dissolved oxygen content of the water to levels which may be lethal to aquatic life. Slash and other logging debris may dam streams, slowing velocity and reducing turbulence. As a result, the inadequate supply of dissolved oxygen may not be replenished. The direct evidence of such water quality degradation is the growth of bacterial slimes and algae which thrive on the nutrients released by organic decomposition.

Clearcutting and other timber harvesting methods can be beneficial in increasing the supply of water available for human use. Much research documents the potential of various cutting practices, properly applied, to increase water yields from forested watersheds significantly. Man-made openings in the forest canopy can cause the following effects:

- increased accumulation of snow in openings;

- reduction of precipitation losses due to interception by the forest canopy and evaporation therefrom;

- reduction of soil moisture losses caused by transpiration of vegetative cover;

all of which result in increased runoff and more available water.

Logging Methods. Falling and bucking of timber causes no degradation of water quality unless trees are felled into or across surface waters. Then, the lopping of limbs and sawing incidental to log making may deposit slash and organic debris in the water. This can cause the reduction of dissolved oxygen and impact on aquatic life described in the preceding subsection.

All of the ground skidding and yarding methods have some potential for significant adverse impacts on water quality, since all cause some degree of soil disturbance. The effect is most pronounced when clearcuttings are logged by tractor, particularly on slopes of 15 percent or more and on saturated soils. The resulting disturbance exposes mineral soil to surface erosion, with consequent sedimentation and turbidity of surface waters caused by materials carried downslope in runoff.

Jammer yarding itself is no more destructive than high-lead or mobile yarder-loader operations. However, the relatively short reach of the jammer makes a dense network of parallel roads necessary for effective jammer operation. If the road system already exists, the jammer can be used without much soil disturbance. If new roads must be constructed to support the jammer operation much soil will be disturbed, probably with severe impact on surface water quality.

Sometimes logs are yarded across streams, or skidded down stream channels by tractors. Both of these practices increase stream sedimentation and turbidity.

Stream clearance by removal of log jam and debris is sometimes required under the terms of a timber sale contract. If heavy equipment enters the stream during the clearing operation, stream sedimentation and turbidity are increased and there is the added risk of water contamination by grease, oil and diesel fuel. Servicing and fueling of logging equipment and log trucks on forest lands adjacent to streams or lakes also can pollute water with petroleum products.

In areas of steep terrain, landings for logs are sometimes constructed by excavating level places where none exist naturally. The excavation may expose large quantities of mineral soil to the impact of rainfall, with resulting ravelling of embankments and downslope movement of sediments with surface runoff into natural waters.

Transportation. Studies have shown that road construction associated with logging, rather than logging itself, is the factor which causes greatest surface erosion and mass soil movement, with resulting degradation of water quality. All of the road construction activities which involve surface disturbance or movement of earth and rock can cause degradation of water quality. These activities include clearing and grubbing, excavation and embankment, installation of culverts, quarrying and grading.

The adverse effects are greatest when midslope roads are constructed by excavation of a "bench" and excavated material is wasted by sidecasting. The excavated materials may be carried downslope into watercourses immediately by gravity or later by surface erosion or sliding and sloughing. Excavation for midslope roads sometimes removes material which supports unstable soils further upslope, with the result that the unstable soil mantle may later move downslope as a mass, sometimes damming a stream.

Construction of drainage ditches and bridges and installation of gabions, etc., in stream channels can cause short term turbidity of streams while the work is being done. Contamination of water by grease, oil and diesel fuel may also occur, if machinery used in these operations enters the water. Improperly installed culverts may discharge surface runoff onto fill slopes, eroding these slopes and carrying sediment into streams or lakes.

The use of petroleum products (oils and asphalt) in road surfacing and surface maintenance can contaminate surface waters. So can the application of herbicides for roadside brush control. These materials may enter water as a result of careless handling or application, or use of excessive amounts, either directly or by movement in surface runoff. Oils and diesel fuels spilled when road construction equipment is fueled or serviced may also enter streams or lakes.

Aquatic Vegetation

Development. Practices such as seeding, planting, mulching, pruning, burying, precommercial thinnings, and hand clearing and cleaning do not usually have an impact on aquatic vegetation. Mechanical brush cutting along streams could temporarily damage aquatic plants while chemicals used to control brush, grass or weeds could kill desirable aquatic vegetation. Area and spot burning could cause short term adverse effects on aquatic plants by killing them if done along streams or beside lakes and marshes. Extensive snag felling in streams or lakes could result in the immediate death of some aquatic plants and long-term environmental changes detrimental to other plants due to deposition of organic material.

The addition of nutrients through fertilization to neutral waters may benefit aquatic plants by increasing their growth. Nutrients carried into lakes, reservoirs and ponds, however, could intensify problems caused by aquatic plants if the receiving water was already rich in nutrients. In such instances indirect impacts could include extreme algae blooms detrimental to uses for drinking, recreation and fish kills due to oxygen depletion during winter or summer months.

Protection. Use of insecticides or fungicides to protect forests would have a direct impact if the chemicals used are lethal to aquatic plants. Fire line construction and backfiring can destroy aquatic vegetation, either directly by killing plants or indirectly by siltation and sedimentation resulting from erosion.

Cutting Practices. Cutting practices which remove most of the timber adjacent to aquatic ecosystems can have a direct impact on aquatic plants. Clearcutting along streams or around lakes, ponds and marshes causes more immediate loss of aquatic plants than other cutting practices. Extensive clearcutting in a watershed may result in undesirable algae blooms, particularly if large increases in water temperatures result from the cutting practice. Under some situations cuttings that result in slight increases in water temperature and more light penetration may benefit aquatic plants by creating better growing conditions. Relatively light cuttings like commercial thinning, selection cutting or sanitation-salvage cutting have minor impacts on aquatic plants.

Logging Methods. Timber falling and bucking, by itself, has no immediate impact on aquatic vegetation unless trees are felled into aquatic habitats thereby destroying plants. Long term adverse effects would occur if debris, slash and tree tops are not removed during logging.

Both short and long term adverse effects on aquatic plants occur when logs are skidded across streams or wetlands, resulting in sedimentation of both running and standing waters. Excessive sedimentation accelerates the natural process of plant succession. This may be beneficial in some developing ecosystems, but sedimentation in most cases is considered detrimental because it reduces the quality and amount of aquatic habitat in the total environment. Crawler tractors and downhill high-lead logging systems generally cause more sedimentation than other ground systems of logging, and would therefore have the most adverse effects on aquatic plants. Aerial systems would cause less sedimentation and loss of aquatic plants than ground systems of logging because logs are partially or totally suspended above the ground during yarding.

Transportation. Studies have shown that more sedimentation of aquatic habitat results from road construction and maintenance than from yarding operations. (See long term impact of sedimentation on aquatic plants as discussed above.) Aquatic vegetation can suffer both short and long term negative impacts whenever construction occurs adjacent to or in waterways.

Aquatic plants may be damaged or removed by clearing and grubbing, excavation of all types of material, and embankment and channelization of streams. Stabilization techniques that use fertilizer could enhance the growth of aquatic plants. Installation of structures in streams may have a slight negative impact on aquatic plants at the construction site.

Maintenance of roads and structures can cause additional sedimentation in water courses which shortens the gradual succession of plant communities. Clearance of landslides from roads can be detrimental to plants if soil and debris are sidecast into streams. Aquatic plants could be damaged by chemical applications to control brush along waterways.

Terrestrial Vegetation

Certain timber management practices may be employed which result in partial to complete, or nearly complete, removal of one or all layers of forest vegetation including the overstory, understory, shrub layer, herbaceous layer and forest floor. Such an impact (removal) may be considered short term since revegetation usually begins soon afterwards with regrowth of residual plant species and invasion by species adapted to open conditions (pioneer species). These pioneer species may be herbaceous or woody vegetation, including tree species, depending upon the local situation. Timber management practices also have long term impacts in the form of time necessary to complete development of a new forest that resembles the one (completely or partially) removed, even when done under ideal circumstances that minimize this time requirement. When conditions are adverse there is little likelihood that the process will be anything other than long term.

Development. The short term impact of scarification, mechanical brush cutting, area burning and chemical weed control is the partial or completed destruction of vegetation. Actions applied to a lesser intensity, may have short term impacts when the removal of vegetation is limited to one vegetative layer or only a small proportion (one-half or less) of the total area. These actions may include scarification in strips or patches, spot burning, burying of slash, chemical weed control of limited number of species, and precommercial thinning. Mechanical trenching and furrowing, spot burning of hand piled areas, chipping of slash, hand clearing and cleaning of competing vegetation, chemical weed control by hand application, mulching, snag felling and pruning have negligible impacts on vegetation. None of the remaining forest development practices damage vegetation. Their short term impacts are related solely to reestablishment, growth and protection of vegetation. These practices include tree improvement, tree seeding, tree planting, baiting, fencing and screening, and fertilization.

All development practices have beneficial long term impacts if they work as intended; trees will be regenerated early and grow at a fast rate thereby developing a new forest without extensive delays. Some practices,

however, may impact vegetation in the reverse of what is intended if misapplied. Examples include (1) scarification that compacts soil, or removes soil or shrub layers that were providing conditions suitable for tree regeneration, (2) area burning that removes desirable (for tree regeneration) shrub cover, causes soil erosion or rapid invasion of other unwanted vegetation, and (3) chemical weed control that removes one type of undesirable vegetation only to have its place unexpectedly taken by another undesirable type.

In general, adverse long term impacts from scarification and area burning are most likely to occur on relatively "warm-dry" sites in all vegetative zones of the Coniferous Forest Biome, especially where soils are shallow and coarse, and humus layer is thin or absent. Long term adverse impacts may also result from use of heavy equipment on wet soils, resulting in compaction. The possibility exists that tree improvement will produce trees that are overspecialized for rapid growth in a commercially desirable form and underspecialized with regard to resistance to disease, drought or other destructive agencies. Finally, tree planting or seeding can represent a tendency toward monoculture where such efforts involve a limited number of species.

Protection. Protection measures benefit vegetation in the long term by insuring continuance of existing forest conditions. The short term adverse impacts of backfiring may include complete, or nearly complete, destruction of vegetation on the burned area. Fire line construction will destroy vegetation directly and also indirectly when excess erosion occurs. Retardants have no known adverse impact.

Cutting Practices. The short term impact of clearcutting is the complete destruction, through tree harvesting, of the upper vegetal layer and the partial damage to the lower vegetal layers in the course of falling operations. Clearcutting produces miles of cutting edge where standing trees are exposed to wind. Subsequently, windthrown trees may endanger adjacent vegetation by providing a breeding ground for insects or fuel for wildfire. Clearcutting may also increase fire danger on cutover area by exposing it to the drying effects of sun and wind until the new forest develops a closed canopy.

From the long term point of view, clearcutting tends to develop a forest that contains trees of approximately the same age and of species that grow well in full sunlight. Assuming no artificial reforestation efforts are taken, the natural rate and degree of recovery will vary by the conditions that characterize the impacted area. Clearcutting on relatively cool-moist sites in certain vegetative zones normally results in the natural regeneration of trees and other vegetation in less than 20 years. These zones include:

Northwest Coastal Coniferous Forest Sub-biome
Western Hemlock Zone
Sitka Spruce Zone

Montane Coniferous Forest Sub-biome
Douglas-fir Zone
Western Hemlock Zone
Mixed Conifer-Mixed Evergreen Zone

Clearcutting on cool-moist sites does not, however, normally produce tree regeneration so fast that herbaceous and other woody vegetation are excluded. There is usually a period during which this vegetation is dominant or thrives in association with tree regeneration. Clearcutting on relatively warm-dry sites in all zones of the Northwest Coastal and Montane sub-biomes, and in high elevation zones where true firs are present normally results in the regeneration of herbaceous and non-coniferous woody vegetation to the virtual exclusion of many coniferous species over extended periods of time, sometimes as long as 25 years or more.

The short term impacts of shelterwood cutting are much less than those of clearcutting, since only a proportion of the total vegetation, usually 50 percent or less, is destroyed or removed. Shelterwood cutting may espose large areas to wind and any resulting windthrown trees may endanger vegetation by providing a breeding ground for insects and fuel for wildfire. Shelterwood cutting also opens the forest to drying effects of wind and sun thereby increasing fire danger, although to a lesser extent than clearcutting. Shelterwood cutting can also perpetuate and spread dwarf mistletoe thereby damaging or possibly killing susceptible tree species.

With regard to long term impacts, shelterwood cutting normally results in the natural establishment of tree regeneration thereby avoiding a long period of exclusive dominance by herbaceous and non-coniferous woody vegetation. Like clearcutting, it usually results in an even-aged forest but favors species better adapted to shade. Shelterwood cutting is often the only feasible way of obtaining early tree regeneration in many zones, especially on warm-dry sites, within the Montane (including the Ponderosa Pine Zone, White Fir Zone and Douglas-fir Zone) but is uncertain in others (Mixed Conifer-Mixed Evergreen in southwestern Oregon); it has also provided early tree regeneration in the Northwest Coastal sub-biome on both "cool-moist" and "warm-dry" sites. This practice opens the forest canopy and allows increased growth of herbaceous and shrub layers although not to the extent of clearcutting.

Seed tree cutting usually impacts vegetation much the same as clearcutting. The number of trees left standing after logging are generally few in number but provide a better chance for natural regeneration and recovery than clearcutting.

Short term impacts of selection cutting are the least of any of the final harvest cutting practices since only a small amount of vegetation is destroyed or removed. Selection cutting does not normally increase danger to forest vegetation from wind, fire or insects due to the absence of large openings or heavy concentration of slash over large areas. Selection cutting can perpetuate and spread dwarf mistletoe thereby damaging or killing susceptible species.

Long term impacts of selection cutting are uneven-aged forests composed of species adapted to shade, including trees of all ages, from seedlings to mature trees. Tree regeneration almost always occurs in small openings soon after mature trees are removed; herb or shrub dominated areas of any significant size rarely occur. The selection method may result in the regeneration of forest trees, on relatively warm-dry sites in the Mixed Conifer and White Fir Zones of the Montane sub-biome. Selective cutting in old growth Douglas-fir forests in the Western Hemlock and Sitka Spruce Zones of the Northwest Coastal sub-biome usually results in the regeneration of only shade loving western hemlock and assorted species of non-coniferous woody vegetation, primarily shrubs.

The short and long term impacts of commercial thinning and mortality salvage are relatively insignificant due to the minimal amounts of vegetation removed.

Logging Methods. The short term impact of ground systems such as tractor skidding and high-lead yarding is to destroy or damage the lower vegetal layers. Logging can cause damage to residual trees resulting in disease, particularly in such species as western hemlock and white fir. Unless extensive soil compaction or loss of soil by erosion occurs the long term impact is to contribute to a relatively early natural regeneration of tree species. Logging methods such as horse skidding and aerial systems do not greatly impact the herbaceous and shrub layers. Consequently, the early development of a new forest is only enhanced where tree species capable of continued growth are present in the understory following falling operations.

Transportation. Road construction practices have a severe short and long term impact on vegetation. In addition to the actual removal of vegetation from the area to be surfaced, road construction frequently destroys vegetation over extensive areas below the road cut or fill where sidecast material (soil, rocks, brush, logs) is pushed by tractors, dumped by trucks or blasted by explosives. Land covered by sidecast is often much slower to revegetate than adjacent land due to sterility of the material and depth to which it covers residual vegetation. Sterile material impedes revegetation by invading plant species and deep covering of residual plants impairs their ability to resprout. Land covered by the road surface is permanently a non-producer of vegetation except for small isolated spur roads that are sometimes abandoned. Even the latter, however, will normally be incapable of producing vegetation similar to adjacent land due to their compacted condition.

In addition to their primary function of log transportation, roads provide positive long term benefits by serving as the means by which men and equipment may be moved into the forest to protect vegetation from fire and insects, and to conduct reforestation efforts. They may also provide recreational opportunities by providing public access to portions of the forest.

Aquatic Animals

Development. The impact of some development practices normally has a stabilizing effect on the watershed, riparian vegetation and the stream channel. Specific actions such as seeding and planting tend to improve the watershed and consequently basic water quality over time and thus benefit aquatic animals. However, actions such as mechanical brush cutting, trenching and furrowing, scarification, burying slash and precommercial thinning may cause short term water quality problems associated with siltation and streambank degradation. Debris could also be deposited in the streams from such operations resulting in a reduction of the oxygen content of the water and blocking fish passage. Area burning and spot burning of piles and concentrations of slash could cause water quality changes if the work is on or immediately adjacent to streams. Impacts would be temporary lethal increases in water temperature and additions of chemicals or ash directly into the water. Chipping, hand clearing, hand cleaning and pruning could add to the organic load of the streams thereby reducing oxygen content. Weed control, precommercial thinning and baiting when conducted with chemicals could cause direct kills to fish, clams, mussels, crustaceans and aquatic insects and drastically harm aquatic communities. Fencing and screening could have a positive impact through protection of overhanging streamside vegetation that provides, (1) a habitat for terrestrial insects that fall into the water and become food for fish, (2) stream shading, and (3) cover for aquatic animals. Snag felling directly into streams may cause blockages to fish migration and add to organic load in the water. Controlled snag felling operations could have a positive effect by providing larger aquatic animals such as fish additional cover in open streams.

Fertilization of watersheds could result in a build-up of nutrients in lakes or reservoirs in the watershed. The small addition of nutrients to some lakes already undergoing eutrophication might amplify water quality problems and cause negative results on aquatic environment. The aquatic biota in neutral waters in high elevation areas of the Montane Forest may actually benefit from increasing nutrients by providing more rapid growth of aquatic plants and animals. The physical operations of moving fertilizer and chance of accident near streams could result in a detrimental impact on aquatic resources.

Protection. Forest protection actions concerned with control of insects and disease through predators and viruses would have little direct effect on larger aquatic organisms such as fish. A drastic reduction in the amount of terrestrial and aquatic insects could, however, have an

adverse impact on fish and crustaceans through the reduction of the insect population used as a food supply by fish. Reduction of insects through insecticides may have two-fold impacts on aquatic organisms. The insecticides themselves may be directly toxic to forms of aquatic life. Those forms dependent on terrestrial and aquatic insects for food may die from lack of nourishment. Fungicides would normally have only a direct impact if the chemicals were toxic to aquatic organisms. Use of insecticides to maintain the general health of the forest and subsequent stabilizing influence on watersheds and water quality is a beneficial long range impact on aquatic wildlife.

Activities during fire suppression work may have detrimental impacts on aquatic animals and organisms. Recent studies show that the most commonly used retardants, both powder and liquid, are toxic to fish and aquatic organisms. Concentrations of around 150 to 200 parts per million in water may be fatal to fish. Direct drops of retardant on small ponds, streams and slow moving rivers may cause concentrations that will produce fish kills. Spills of retardants near assembly areas and airfields with subsequent drainage into stream systems may be lethal to aquatic animals. Fire line construction, especially with track vehicles, can cause subsequent erosion problems especially on steep grades. Backfiring, as a method of fire control, may cause destruction of additional stream riparian vegetation and result in loss of cover and degradation of water quality for fish and other aquatic animals.

Cutting Practices. The primary impacts on aquatic animals from various forest cutting practices occur as a result of the removal of protective vegetation along streams and the deposit of debris and sediment in streams. Commercial thinnings, intermediate shelterwood cutting, selection cuttings and other partial removal cuttings probably have the least negative impact on water quality and streamside environment. In fact, water quality could be improved as a result of these practices by subsequent increases of vegetation on the forest floor and protection of the watershed. Clearcuttings will have an immediate detrimental impact on water quality in areas where trees adjacent to the stream or river systems are removed. Elimination of the forest canopy and riparian vegetation can increase water temperatures over optimum limits. Any erosion originating on the clearcut area can result in the degradation of water quality in adjacent water bodies through sedimentation and siltation. Changes in annual water flow caused by this cutting practice could produce either positive or negative impacts depending on the biotic requirements of the animal.

Logging Methods. The impact of falling and bucking on water quality and the aquatic environment is immediate and may cause short term problems. Falling methods that permit a large concentration of trees and debris in streams cause adverse impacts by the addition of organic matter which reduces oxygen in the water and stream blockage. Accidental spills of oil, gasoline, and other materials used with falling equipment may add undesirable ingredients to small tributary streams and be toxic to aquatic organisms.

The movement of logs by ground skidding or yarding operations can have a significant impact on the water quality of streams and lakes by the addition of sediment, causing siltation and excess turbidity during periods of heavy runoff. Streambanks and bottoms could also be damaged and scoured. The heaviest impact may be from crawler tractor skidding due to erosion and severe disturbance of the soil mantle. Horse and rubber tired skidding normally cause less soil disturbance and less subsequent deposits in the stream environment. Various types of aerial yarding systems have less direct impact on aquatic habitats.

Large amounts of debris left on stream bottoms following the logging operation can be destructive to aquatic animals, especially fish, clams and mussels, and aquatic insects and crustaceans. Degradation of habitat comes from lower dissolved oxygen through addition of organic material, increased water temperatures and physical damage to the stream bottom and banks. Large logs and heavy debris left in steep draws and along streambanks may cause long term drainage problems which result in destruction of fish populations and stream habitat. Sluice-outs, during periods of heavy precipitation, cause complete destruction of the aquatic habitat from physical changes of the environment. Offsite degradation of aquatic environment is common from sediment and debris in lower river systems and estuaries.

Transportation. Studies in most western states show that road construction has one of the most serious impacts on water quality and aquatic life in general. The impacts are associated with soil disturbance during the construction phase. The action may result in stream channel changes, blockages to fish and addition of sediment load to streams so as to reduce aquatic organisms. There are also drastic changes in the aquatic habitat with subsequent reductions in spawning success and condition of higher animals such as fish. The proximity of the road to the stream is a factor in the magnitude of the impact.

Clearing and grubbing pose immediate problems of debris blocks in streams and temporary turbidity from siltation. Excavation of earth and rock, if located near streams, will add silt load and increase turbidities which are destructive of aquatic organisms. Excavation and removal of spawning gravels in streams may destroy historic spawning grounds for both anadromous and resident fish. Rock and gravel in streams are usually food producing areas. The immediate effect is destruction of aquatic insect habitat. The long range effect is the reduction of food for the larger organisms such as fish and crayfish.

Improper embankment and compacting and grading may cause subsequent erosion that adds sediment to streams and impairs some of the habitat requirements. Stabilization techniques usually have a positive influence on aquatic animals by improving water quality.

Rock crushing may require washing operations. Resulting sediment load from these operations may reach streams and smother habitat of

aquatic insects, mollusks and crustaceans. Spawning gravels are generally impacted with fine material and water quality degradation below standards may result. Bases and surfaces of roads may contain materials detrimental to aquatic organisms when washed into streams. Examples are clay and dirt surfaces that deteriorate during periods of heavy rainfall or freezing and thawing.

Drainage ditches and culverts may concentrate waters to flow on erodible fill areas causing sediment deposits in streams. Structures in streams such as culverts, bridges, fords, and other crossings may become impassable barriers to migrating fish. Construction in streams at improper times and exposing materials such as portland cement and asphalt to streams may cause fish kills.

A variety of impacts to fish and other aquatic organisms may be caused during maintenance of roads, trails and other access routes. Drainage structures may be altered on roads, causing undue addition of silt and debris in streams. Repair of structures on stream crossings or of riprap may cause destruction of spawning beds or delay in migration of adult anadromous fish. The sidecast of debris and slides during removal operation into streams may cause degradation of water quality for many miles below the problem area. Brush control along stream side roads may not be compatible with existing aquatic habitat and water quality. Excess destruction of vegetation may increase water temperature and destroy cover. Herbicides entering streams through various routes can directly kill aquatic animals.

Terrestrial Animals

Development. Tree improvement practices may increase the growth rate of coniferous forests, thereby adversely affecting browsing animals such as deer by reducing the time that they can use the reforested area. Forest dwelling species including some birds, small mammals, and mammalian predators may benefit through the cover afforded by rapid forest regeneration.

Scarification, mechanical brush cutting, burning, and chemical weed control, etc., will have a temporary adverse impact on small ground dwelling mammals such as brush rabbits, mice, moles, shrews, and a few ground nesting birds (e.g., mountain quail, grouse), and on deer and elk by eliminating brush cover.

The burning and burying of brush and logging slash would be detrimental to small ground-dwelling or nesting mammals, birds, reptiles and amphibians, but benefit larger animals since it permits ease of movement, and allows the growth of valuable browse species.

Chemicals such as 2,4-D and Atrazine may destroy the cover used by small mammals, amphibians, and reptiles. Extensive use of chemicals deny wildlife use of extensive areas during crucial periods such as winter and spring. Use of defoliants such as 2,4-D in large stands of alder and

other hardwoods remove necessary escape cover used by deer, elk, and other animals and birds. Use of Atrazine may at times be beneficial to browsing animals by removing grass competition with browse species.

Seeding and planting promotes or augments natural reforestation and may hasten the time interval of natural regeneration (see tree improvement above). If the seed or planting stock is treated with non-toxic repellents, such as thiram, there would be little effect on wildlife. However, rodenticides such an endrin and strychnine can cause losses to predators that have eaten the poisoned animals.

Baiting would be most detrimental to many small mammals including mice, some shrews, ground squirrels, woodrats, porcupines, hares and rabbits, mountain beaver, moles, and gophers. If strychnine is used, predators, either avian or mammalian, could be killed by the secondary effects of the baits after eating dead or dying rodents that had ingested the poisoned baits. Herbivores may at times benefit through the baiting and subsequent control of overpopulations of mice, rabbits, and gophers that may be destroying browse species by girdling, etc.

Fencing and screening can be detrimental to animal movements if conducted on an intensive basis. Little impact would occur by screening individual trees, but extensive fencing can interfere with normal animal movement, and can entrap the young of deer and elk. Adult animals can become entangled in nylon-mesh fencing used in some planting sites.

Snag felling can have an adverse impact on many birds and small animals that use snags for denning, nesting, and food storage. In addition, spike tops, and large dead snags are needed near eagle and osprey nest trees for perching, and for the young to use when learning to fly. Larger dead snags or hollow trees are often used by furbearers including some of the larger predators. (See remarks under cutting practices.) Snags and dead trees also harbor insects that furnish an extensive food supply for many insect-eaters including woodpeckers and creepers.

Fertilization. Applications of superphosphates and other high nitrogen content fertilizers greatly increase the palatability and general use of almost any treated plant species by herbivores and rodents.

Precommercial thinning and pruning may benefit wildlife dependent on a brush understory by opening up the canopy and allowing sunlight to reach the forest floor. Since sunlight influences both the quantity and quality of forage, browsing animals would generally benefit from thinning practices.

Protection. The control of a pest species by another insect species is generally of no consequence, from a wildlife standpoint, beyond the immediate effect of the predator on the prey. Habitat used by wildlife can be destroyed by infestation of borers, leafeaters, sap feeders, and other insect pests. Webworms can destroy forage needed by wintering deer,

but the caterpillars may, in turn, provide a valuable food source for many insect-eating birds.

The use of chemical insecticides is of more immediate consequence to wildlife. The use of DDT, for example, has had catastrophic effects on many forms of bird life, both by killing them outright, eliminating food supplies, or disrupting their reproduction. Other insecticides used to control damaging species may also kill non-target insects including predatory species.

Cutting Practices. Nearly all wildlife are initially affected adversely by the sudden impact of timber harvesting. The immediate removal or destruction of habitat including food supply, nesting, fawning, calving, wintering, and escape cover can result in the drastic displacement or actual loss of small birds and mammals. Since most wildlife are highly territorial, displacement can be as fatal as the actual harvesting effects, as most suitable habitat is already fully occupied.

Differences between cutting practices is a matter of degree of damage to wildlife with clearcutting and seed tree cutting generally the most damaging, and selective cutting the least damaging. Shelterwood cutting probably occupies a model position in this regard.

Some species of wildlife, however, are quite tolerant of, or respond favorably to, the actual removal of the forest overstory and subsequent human activity. Deer, especially blacktailed deer, respond favorably to the removal of closed canopies and subsequent availability of nutritious browses, grasses, and forbs. Rodents, including ground dwelling squirrels, mice, and rabbits usually increase with brush conditions following logging. Small predators that would prey on these rodents would also benefit. Roosevelt elk are also usually benefitted by timber harvesting activities, if it consists of scattered small clearcuts.

Most large mammalian and avian predators are adversely affected by extensive loss of cover and accompanying human activity. In general, both clearcutting and partial cutting practices affect wildlife species (to varying degrees) prior to return to a closed canopy condition as follows:

Beneficial Impacts	Mammals	Adverse Impacts
Deer (blacktailed)		Bear
Roosevelt Elk		Cougar
Snowshoe hares		Mink
Ground squirrels		Fisher
Mice		Marten
Moles		Tree mice
Bobcat		Flying squirrel
		Mountain beaver
		Shrew

Beneficial Impacts	Adverse Impacts
Birds	
Blue grouse	Eagles
Ruffed grouse	Ospreys
Mountain quail	Northern spotted owl
Bandtailed pigeon	Chickadees
Sparrows	Nuthatches
Thrush	Winter wren
Wrens	Accipiter hawks
Junco	Franklin's grouse
Warblers (some species)	Dippers (water ouzel)
	Woodpeckers
	Warblers (some species)
Amphibians and Reptiles	
Toads	Salamanders
Lizards	Tree frogs
Garter snakes	

Many small mammals, small owls, and woodpeckers are indirectly affected by logging where the cutting of merchantable trees also means the loss of snags and dead trees. Other birds dependent on cavity nests include tree swallows, titmouse, creepers, and near waterways, wood duck, bufflehead, golden eye, and the hooded merganser. Animals can include squirrels, mice, fisher, marten, bats, raccoons, ringtailed cat, and bear.

Logging Methods. Ground systems that disturb the soil stimulate browse production favorable to herbivores. In general, crawler tractor skidding, high-lead yarding, mobile yarders, and jammers, create soil disturbances beneficial to animals dependent on grass and browse production. Small mammals and ground dwelling birds, amphibians and reptiles will obviously be destroyed or temporarily displaced by this type of operation.

Most wildlife benefits, however, would accrue from horse skidding and skyline, balloon and helicopter yarding which causes a minimum of disturbance. Again, slash distribution and disposal is of importance; much standing slash impedes movement of larger animals such as elk and deer, but encourages mice, ground squirrels, rabbits, hares, and other small mammals and birds that are normally found at or near ground levels.

The aerial types of yarding would be less prone to destroy snags and dead trees through normal logging attrition than would high-lead and ground skidding systems. As mentioned previously, snags and dead trees are of great importance to many birds and mammals. Another advantage of aerial yarding is that it reduces much of the road construction necessitated by

more conventional methods. Roads greatly reduce the available wildlife habitat, and cause many species to abandon former habitat because of greatly increased human disturbance.

Transportation. Probably the greatest adverse impact on wildlife stems from road construction. As with timber harvesting, there is an initial sudden and disruptive effect on nesting and sometimes wintering wildlife. Also, road rights-of-way permanently remove thousands of acres of wildlife habitat, encourage harassment of wildlife through ease of vehicular access, and preclude use of vast areas to wilderness-inhabiting species. While the larger predators, both avian and mammalian, are the most adversely affected, there are probably few wildlife species that are directly benefitted by road construction and use. Obviously, some "edge" effect along roads is created in closed canopy environments that will be used by some species of birds and animals, but effects are still basically negative. The deer or grouse using roadside grass-legume bank stabilization seedings may be killed by the speeding vehicle or road hunter.

Road construction and use can adversely affect wildlife if routed through fawning, calving, or bedding areas, or through crucial winter ranges. Many species require a wilderness aspect and will be driven out of specific areas by the human activity associated with roads.

Ecological Interrelationships

The unmitigated impact of each timber management practice on each of the physical and biotic components making up the environment or ecosystem are discussed individually in the subsequent parts of this section. This part will attempt to deal with the overall impact of the program on ecosystems in a collective sense, thereby avoiding unnecessary repetition.

Unfortunately, the nature of many chain-like relationships in the cycles and flows that link the components of the ecosystem are not known or understood. It can be assumed that impacts on one part of the ecosystem will affect the whole. However, the manner and magnitude in which the total ecosystem is affected is often unknown or vague at best. Some information does exist for impacts of specific practices in particular locations on parts of the ecosystem which may be indicative of the impact of the same or similar practices conducted in other locations.

As an example, an experiment in New Hampshire in 1965 concluded that clearcutting tends to reduce the nutrient capital of a forest ecosystem by: (1) increasing the amount of water passing through the system, (2) by reducing root surfaces able to remove nutrients from the leaching waters, (3) by the removal of nutrients in wood products, (4) by adding to the organic matter available for immediate mineralization, and (5) in some instances by producing a microclimate more favorable to rapid mineralization.

Another example was a study made in western Oregon in the 1960's, which examined the impact of scattered clearcuts (with streamside buffer strips) in one drainage and a large clearcut extending across a stream in another drainage. No changes were observed in the nitrate nitrogen, potassium, and phosphorous content in stream water in the scattered clearcut drainage. There was a four-fold increase in nitrate nitrogen loss in the large clearcut following logging and burning. The study concluded this amount of loss posed no threat to forest soil productivity in the study area since the soil contained high nitrogen capital due to its capacity for holding and storing nutrients, and that rapid revegetation limits future nutrient loss by quickly reestablishing the cycling process. However, the study also concluded that the micro-organism and cutthroat trout populations of the stream in the clearcut drainage were adversely affected, thereby disrupting the ecological interrelationships of the aquatic ecosystem.

The application of the results from these and other studies must be interpreted with respect to the specific conditions that characterize the impacted area. These include soil, topography, climate, vegetation, the design of the clearcut area(s) and the method of logging. It may be safely assumed, however, that the application of any chemical, burning or mechanical timber management practice that completely destroys terrestrial and aquatic vegetation will have a severe short term impact on the ecological interrelationships of the impacted area. These actions remove the sole producing component of the ecosystem upon which all other members of the biotic community depend, either directly or indirectly.

Any resulting reductions in population densities of the living components of the community due to mortality or relocation may only be temporary. Nonetheless, the ecological interrelationships of the impacted area and possibly of offsite areas are disrupted. If the ecological interrelationships in adjacent undisturbed areas are in delicate balance, the relocation of such animals as deer, elk, etc., may further extend the impact of the action. Therefore, the severity of the short term impact is not always localized to the directly affected area but is dependent on the ability of adjacent areas to absorb increased animal populations, which in turn is partly a function of the nature and magnitude of the action itself.

While the physical impact of timber management practices on vegetation are readily visible, impacts on the micro-organisms in the soil that act as decomposers are indiscernible and perhaps more subtle. Nonetheless, they constitute a vital link in the trophic hierarchy and their elimination or reduction due to chemicals or severe soil disturbance practices can also result in significant adverse short term impacts on the ecosystem.

The long term impact of most practices on the ecosystem is primarily dependent upon the rate of recovery of the area affected, either directly or indirectly, which varies with its physical and biotic characteristics.

Generally, communities with high productivity in terms of the vegetal biomass can recover relatively rapidly. Communities with low productivity, i.e., plants with low growth rates and animals with low reproduction rates, are generally fragile and slow to recover. Consequently, the long term impacts of any of the development, protection, harvest and transportation practices that destroy vegetation and/or cause extensive surface disturbance can be particularly severe in the sub-alpine and alpine zones of the Montane Forest. Other localized areas within the Montane and also in the Northwest Coastal are fragile and highly susceptible to severe impacts on the ecosystem if disturbed.

Relative to the potential impact on the biotic components of the ecosystem, the impact of timber management practices on the atmospheric components of the physical environment are considerably less. Although burning practices do release some particulates into the air, their impact is minimal in terms of human health. These particulates appear to have no impact on the ecological relationships within the forest environment.

Even though the impact of any one practice on any one locale may be severe, its significance will probably be greatly diluted when viewed in the context of the size of the impacted locale in relationship to the size of the surrounding geographic area. Nonetheless, many practices are conducted in different parts of the forest at the same time, and in total can cause a severe cumulative impact to the ecosystem of the general area. Individual practices, including those having little adverse impact, continuously carried out over time can have a significant cumulative adverse impact on the ecosytem at some point in the future.

Human Values

The former parts of this section dealt primarily with the direct unmitigated impacts of timber management practices on the biological and physical components of the forest community. This part and the next will expand the community dimension so as to include man. The basic underlying assumption used in describing these impacts is that timber management will be given precedence, partially or wholly, over all other potential uses.

Settlement. Scattered throughout the Coniferous Forest Biome are many small communities and isolated farms, ranches, vacation retreats and mining camps. Where timber management activities are taking place near such human habitation there are risks of adverse impacts occurring.

Health and Safety. Human health and safety can be affected by some forest development practices. Aerial spray of chemicals for brush and weed control, if allowed to drift and settle on inhabited areas, or enter food supplies, streams or open water, can be injurious to human health and welfare.

Smoke from slash burning may have temporary adverse effects on people with respiratory problems. Visibility may at times be restricted where slash burning occurs near roads and highways, creating hazardous driving conditions. These conditions may also occur in conjunction with quarrying and rock crushing activities associated with road construction.

Where logs are being hauled out of the forest there is always the danger of collisions with motorists and others using the logging roads.

Hazards to the health and safety of workers, both government and industry, can occur in practically all phases of the timber management program. Accidents leading to death and injury most commonly occur during harvesting and removal operations.

Employment. No significant adverse effects on employment are felt to be associated with timber management. The frequent, sometimes sharp price changes in the timber industry do effect rates of employment, particularly in wood processing and manufacturing, however, this is not an explicit program impact. On the other hand there are obvious beneficial effects on employment. Many jobs are created as a direct result of the timber management program. Other jobs, performing services for the timber related employees, are also created.

Local and Regional Economies. There are no known adverse impacts on local and regional economies. In fact, timber production is the basis for many local economies, particularly in the Northwest Coastal Forest. Other regional economies are benefitted to a lesser degree.

Mineral Development. The BLM lands in western Oregon are subject to the general mining laws. In essence this means that the lands are open for prospecting and for the filing of mining claims, and for the eventual patenting of the mining claim if a valid discovery is made. Prospectors must comply with a State of Oregon statute which calls for obtaining a permit and meeting certain environmental restraints and filing a reclamation plan.

Any hindrance of mineral prospecting activity by the timber management program would be psychological rather than statutory or administrative. A prospector may think twice before prospecting in an area on which obvious investments have been made in tree planting, thinnings, etc., but there is no legal restraint to prevent him from doing so.

The timber management program will have little effect on mineral-related activities in western Oregon.

Wilderness. Few, if any, BLM commercial forest lands in western Oregon meet the basic criteria (established by Federal legislation) necessary for classification and formal withdrawal as wilderness; i.e., vast areas untrammeled by man, with no evidence of his presence.

Nevertheless, some public values might be jeopardized by conducting a timber management program in areas where the aesthetic values of scenery and open space might be viewed as semi-wilderness in character. An example would be the opening up of an extensive area of old-growth timber to harvesting, thereby destroying its intrinsic virgin values.

Recreation. The variety of recreational values and the broad array of timber management practices make many land use conflicts inevitable. Although some recreational activities may be benefitted by the timber management program, others will not. Quite often a practice may be both beneficial and detrimental at the same time, the choice being dependent upon the user's point of view. As an example, for many years following logging, a clearcut area may have lost all apparent value to a camper or hiker. However, its invasion by vegetation may produce forage for wildlife, making the clearcut attractive to hunters and berry pickers. As another example, surface runoff from a newly constructed, unstabilized forest road will cause some turbidity and sedimentation of streams, with a short term adverse effect on fishing success and water sports. The same road may provide access for hunters, berry pickers, rockhounds, bird watchers, and campers.

Setting aside these often subtle distinctions, timber management practices usually result in adverse public reaction, particularly in areas of heavy recreational pressure (usually near population centers); in situations involving unique or rare ecosystems or scenery; and where natural attributes create a high recreation potential. The reaction may be justified in that timber management, particularly harvesting practices, will most often destroy the values or uses which the public is seeking. The apparent destruction of the forest and the accompanying activities in the form of logging truck traffic, chain saws, road building, etc., represent both realistic and psychological adverse impacts on recreational values. If timber management practices were uncontrolled throughout the forest many of its recreational values would be significantly impaired or destroyed.

Grazing. Implementation of some of the proposed practices can deny the use of Federal range to some grazing permittees and lessees, temporarily or permanently; e.g.:

- Area burning of a forest range after clearcutting will consume grasses and annuals, and often browse, thus temporarily eliminating or reducing available livestock forage. If seeding or planting will be used to regenerate the forest after burning (as is customary), it may be necessary to exclude livestock from the treated area for several years, to permit the new stand of trees to develop without exposure to animal damage. A more far-reaching administrative decision may exclude livestock from the treated area permanently, on the ground that forest values are too great to risk the effects of browsing and soil compaction that livestock can cause.

- Chemical weed and brush control might require that livestock be removed from the area to be treated prior to herbicide application. Their return might have to be temporarily deferred until chemicals have degraded to safe toxicity levels or, if the area treated is to be reforested, exclusion of livestock may be long term or permanent.

- Various cutting practices (particularly clearcutting) can create more livestock forage. However, grazing may conflict with the silvicultural objectives chosen for treated areas, so that livestock must be excluded.

- Roads built for log transportation may impair a livestock producer's full utilization of allotted Federal range or of his own private lands. Log truck traffic can injure or kill domestic livestock.

Conflicts between the timber management program and livestock grazing will be most significant in the Montane sub-biome. Short term or permanent losses of forage and other impairment of range livestock operations attributable to the timber management program are insignificant in the overall production of meat to satisfy national needs. However, these adverse impacts may be highly significant to the individual livestock producer.

Agriculture. Where agricultural land uses involving row crops or orchards are located near timber management activities, some adverse effects could happen. Aerially applied herbicide use in forest development activities could drift and settle on adjacent agricultural lands or on waters used for irrigation.

Practices that disturb the soil, causing erosion and stream sedimentation, such as scarification, land clearing and cleaning, area burning, log skidding, and road construction, can have adverse impacts on downstream agriculture dependent upon the forest watershed for irrigation water. Silt can fill downstream reservoirs, shortening their life, enter and clog irrigation systems, and harm crops when deposited on the fields.

Clearcutting and other harvesting practices, on the other hand, can also increase available downstream water by opening the forest canopy. This can allow increased accumulation of snow, reduce precipitation losses due to interception by the forest canopy and evaporation therefrom, and reduce soil moisture losses caused by transpiration of vegetative cover.

Commercial, Residential and Industrial. Adverse impacts that may affect human settlement in general were discussed above under Settlement. There are few other instances where the timber management program would adversely affect commercial, industrial or residential land uses.

Intensive timber management operations carried on adjacent to residential or commercial development could, however, lead to severe conflicts.

Where blocks of privately owned lands intermingle with BLM forest lands, the development of recreation subdivisions or ski resorts can precipitate conflicts. Timber management practices that disrupt the adjacent forest aspect can adversely affect such developments. In addition to potential impacts on health and safety discussed previously under Settlement, senses of sight, sound, and smell can be offended.

Local Government and Public Services. Timber management practices can have direct and indirect adverse impacts on state and local government operations and planning. Physical disruption of public services such as gas, electric and water facilities can happen where utility rights-of-way cross timber management areas.

State and county roads and bridges can be affected by increased log truck traffic, leading to increased maintenance costs to local governments.

Development of BLM transportation systems related to timber management operations could conflict with local government plans and objectives. Where roads cross or pass close by state and local government lands, these lands may suffer from increased public use.

Aesthetics. With few exceptions, the impacts of timber management practices on aesthetic values are adverse. Impacts of greatest magnitude are visual, but sound, odor and mood are also involved.

Any action that produces a visible change in the natural forest environment can cause an adverse human reaction. Among development actions with highly visible effects are prescribed burning of slash (atmospheric smoke, charred forest floor); scarification (dust during the operation, disturbance of surface vegetation and soil); chemical weed and brush control (dead vegetation); and precommercial thinning (slash). Noticeable evidence of protection actions includes fire lines and, if identified as such, the burned areas resulting from backfiring.

Cutting practices and logging operations are attracting increasingly critical public notice. Clearcutting in particular has been condemned by some groups, largely because of the visual impact of extensive poorly-designed clearcut areas. Some logging operations, and particularly subsidiary road construction, create visible soil disturbance and atmospheric dust. The soil disturbance alone may be visually objectionable; it can also be the source of sediment which, carried in surface runoff, spoils the clarity and color of natural waters. Heavy log truck traffic over dirt or gravel roads may create clouds of dust which seriously impair visibility.

Any of the timber management activities may leave such residual litter as discarded tools or equipment accessories (e.g., broken shovels, axes, wire-rope chokers and worn-out truck tires), empty fuel or herbicide containers, lunch wrappers, etc. as evidence of human presence on the land.

Reaction to the unsightly effects of timber management actions will vary in intensity with the individual viewer. The range of human attitudes does not lend itself to a discrete classification on a graduated scale. However, some interest group reactions can be considered generally typical:

- Members of a community dependent on a forest-based industry are more inclined to accept the adverse visual impacts of timber management actions.

- Hunters, fishermen, rockhounds, berry pickers, family-type campers, and off-road vehicle enthusiasts tend to appreciate the easy access to the back country provided by logging road networks. This appreciation may or may not outweigh the individual's objections to unsightly conditions created by forest development and timber harvesting activities. Emotions may be mixed.

- Backpackers and wilderness advocates usually prefer the forest environment in its original condition, without man-made modifications. These people may react most strongly to any unnatural change in the landscape. They often oppose proposed roads which would open back country areas to vehicular travel.

The adverse visual impacts of timber production are partially offset by some incidental visual benefits. Sometimes logging road construction opens up an impressive scenic vista which otherwise would be unappreciated. Clearcuttings and vegetative erosion control measures produce forage which attracts wildlife for easy viewing by amateur naturalists.

Sound, Odor and Mood. Even gregarious campers would tend to avoid proximity to a noisy logging operation or mechanized forest development project. Certainly a hunter would avoid such a locale; a fisherman seeking mental relaxation would, too. The diesel fumes and dust from such operations would be unpleasant to most recreationists. The combination of sound and odor could shatter the mood of the soil-seeking wilderness advocate.

Geology. Areas containing unique geologic structure occur in both the Montane and Northwest Coastal Coniferous Forests. While most actions related to timber management would have little if any adverse effect, road construction could have a severe impact on these natural features. Excavation of earth and rock during construction could irreparably alter natural arches and caves, ruining their visual quality.

Severe alteration of the vegetative cover, such as by clearcutting and brush removal, can also create ill effects on visually important geologic features.

Archeology. Archeological sites are most valuable to both the scientist and the sightseer when they are undisturbed. Actions such as road

excavation, quarrying, and site preparation activities that disturb the soil on or around archeological sites will reduce or destroy their values.

Roads into areas of archeological significance could create major impacts by providing easy public access to vandals and looters.

History. Many old cabins, stagecoach rest stops and abandoned mining camps lie scattered throughout the Montane Coniferous Forest. Remnants of old wagon trails occur in most of the coniferous forests.

Severe disturbance or alteration of the vegetation near historic sites will disturb the visual setting and weaken their human interest values.

Soil disturbance or alteration of the landscape by road construction, and site preparation for revegetation of cut-over areas can obliterate old trail remnants. Road access into historic sites can subject them to vandalism.

B. Possible Mitigating Measures

Many mitigative measures set forth in this section are initially brought to bear during the land use and MFP planning phases, as described previously.

Later, these and other measures are carried out in the course of planning a practice and in executing it through contract stipulations and contract administration. These actions represent the administrative framework within which mitigative measures are identified and implemented. Consequently, the effectiveness of all of the measures described in this section is dependent upon sound planning, coordination with other resource activities, professional expertise, careful on-the-ground administration and cooperation from the contractor or user. Since these requirements are common to all mitigative measures they will not be repeated in the parts that follow.

Air

Development. Troublesome smoke from burning practices can be mitigated by integrating burning schedules with weather reports to produce as fast and hot combustion as practicable and facilitate movement of smoke away from populated areas. Burying slash and chipping reduces the volume of fuel to be disposed of and thus reduces the need for burning and the resulting smoke emissions. However, both burying and chipping are rather costly measures and are not commonly employed, except for the burying of right-of-way slash which is becoming a more common practice. More intensive utilization of felled timber holds promise for future abatement of the smoke problem.

The adverse impacts of prescribed burning and brush removal upon local climatic factors are decreasing in magnitude as more knowledge is made available by research and is applied to field operations.

In situations where prescribed burning or brush removal are essential, their adverse impacts on micro-climates may be non-existent or insignificant. If considerable impacts are anticipated, the following mitigating measures may be used:

- Adverse impacts may be reduced by keeping the areas to be treated small. The growing trend toward smaller-size clearcuttings favors this means of mitigation, particularly in the case of area burning. The beneficial effects of partial brush cover, where desired, may be retained by spot removal rather than broad area treatment of brush.

- If a light burn will achieve silvicultural objectives, its application can be timed for a period when burning conditions will favor an easily-controlled fire of low intensity. Fire equipment

and manpower can be put on standby status for emergency use if burning conditions should change or if the fire escapes. It will often be necessary to build a fire trail around the project area before treatment begins.

Protection. The adverse impacts of backfiring on micro-climates can be mitigated by the same measures as those used for area burning by:

- Keeping the backfired area as small as feasible, consistent with the objective of controlling the wildfire.
- Backfiring, if possible, when burning conditions will favor easy control.
- Safeguarding the backfire by burning from a road, fire trail or natural barrier.
- Maintaining adequate manpower and equipment on standby.
- Revegetating the burned area with suitable species as soon as possible.

Cutting Practices - Logging Methods. If the site is dry and exposed to solar radiation and drying winds, the cutting practices employed should provide shade which will reduce surface soil temperatures and evaporation. In forests susceptible to windthrow, any clearcutting should be designed to fit topography, so that strong winds will have minimum effect on the edges of the reserve stand exposed by harvesting. If this is not feasible, shelterwood cutting should be employed. No mitigation is necessary for the slight adverse effects of logging methods on micro-climate.

Transportation. The effect of right-of-way clearing upon the local climate can be reduced by keeping the width of clearing as narrow as possible, consistent with safety and adequate visibility. No effective measures are presently available to reduce the short term degradation of air quality by the emission of internal combustion engines used on road construction machinery. Dust arising from construction may be reduced to some extent by watering of subgrades during blading and surfacing operations. Aerial dust from log hauling by truck can be abated by oiling roads or surfacing them with bituminous material or macadam. On dirt or gravel surfaced roads, periodic application of water or waste sulfite liquor effectively reduces the dust problem.

Land

Development. Scarification should be conducted when the soil is dry and limited to the area necessary to accomplish the task. Contoured strips or patches should be used when feasible and all scarified areas revegetated as quickly as possible with the desired species. Mechanical brush cutting should not be conducted when soils are wet. Mechanical trenching-furrowing

should be conducted on the contour and the exposed soil immediately revegetated. Width should be kept to an absolute minimum and unstable areas avoided. Burning should not take place on shallow or erosive soils when conditions are such that a "hot" burn will consume all the litter layer. On critical sites, a mulch should be applied to protect the surface from erosion until vegetation is reestablished. Shallow ($<$ 20" deep) soils occurring on southerly exposures should not be subjected to burning. Trenches for burying slash should be constructed and the topsoil stockpiled and respread on the surface, after the trench is filled.

Hand clearing and cleaning should be limited to as small an area as possible to accomplish the task. A mulch could be placed on the site in addition to an appropriate amount and type of fertilizer if critical soil conditions exist. Improper application and spills should be avoided during chemical weed control and a cover of desired vegetation established as soon as possible. Precommercial thinning has a minimal impact on the suppression of available soil nitrogen; however, its impact may be eliminated by conducting the operation in conjunction with fertilization operations. Care should be exercised when fueling equipment or filling chemical injectors.

Protection. Fire lines should be constructed on the contour when feasible and subsequently water-barred and revegetated. Hydromulch can be applied to provide immediate protection. The fire line can be scarified to loosen compacted soil if the line also served as a trail for vehicles. Areas burned as a result of backfiring should be revegetated the same year as the fire.

Cutting Practices. Clearcutting, and to a lesser degree, seed tree cutting practices should not be carried out on slopes where the potential for excessive erosion or mass wasting exists. Factors affecting slope stability which should be considered include slope gradient, thickness of the soil mantle, character of the underlying bed rock, precipitation patterns, and the inherent strength of the soil. When these factors appear critical, other cutting practices should be considered. When these other practices, such as selection, shelterwood, etc., are not feasible due to silvicultural, economic, or technical constraints or the potential hazard remains despite the system of cutting employed, the area should be exempted from commercial timber production. See Oregon State Office Manual Supplement 5250.1 for guidance.

Logging Methods. Tractor logging should be limited to slopes with gradients of less than 35 percent regardless of the potential of the soil for compaction. Tractor skidding should not be permitted down or across any stream channel. Tractor skidding should be limited to those seasons and sites where soil moisture is low enough to avoid compaction, rutting, or gouging of the soil. Operators should not be permitted to clear a skid road for one or two trees. Since jammer yarding requires a closely spaced network of roads, adverse impacts can be reduced by confining these operations to existing road systems; i.e., if new roads must be constructed

alternative logging methods should be used. In steep topography, aerial systems should be used wherever feasible, particularly on areas of unstable fragile soils. Landings should be located so as not to create excessive sidecast or slope stability problems. Landings on highly productive sites should have the topsoil stripped and stockpiled. After use, ripping may be necessary to mitigate soil compaction, and the stockpiled material should be redistributed over the landing. To reduce the potential for slope failure in steep terrain, decking of cull logs at the edges of landings should be avoided.

Transportation. Road alignment and design have important effects on roadside erosion and effective control must begin in the design phase, since the location of a road determines to a large degree the amount of erosion which may occur. The selection of the road corridor provides the opportunity to place a road in favorable relationship to topography, drainage ways, soils, other natural features and present or anticipated man-made features in order to minimize the base erosion potential.

Clearing and grubbing should be conducted so as to minimize the area of soil disturbance. They should be coordinated with grading so that ground disturbance due to grubbing will not be exposed longer than necessary. As is the case of most construction activities, clearing and grubbing should not be carried out during periods of wet weather and poor soil conditions.

To minimize erosion due to excavation, the total length of road cut should be minimized, but the vertical depth of each cut should be maximized. Thus, large quantities of material will be obtained at a single location. Cut slopes and ditch gradients should be flattened in order to reduce the number of cuts, thereby reducing erosion hazard.

Borrow areas should have the top soil stockpiled, be shaped to natural contours, have the topsoil redistributed, fertilized and revegetated. Removal of the contour hump in a hill cut will decrease the erosion potential and makes maintenance easier. Borrow pits should be well drained unless suitable for pond development. If not, they should be shaped, sloped, seeded, fertilized, and mulched.

Factors involved in the design of fills in embankment work are height, stability of slopes, stability of foundations, and the selection of embankment materials. All major fills (heights greater than 30-40 feet) should be subject to stability analyses and designed in accordance with established principles of soil mechanics. Construction of embankments should be done by placing the earth in layers and rolling to a specified density usually in the range of from 90 to 100 percent of standard AASHO maximum density before applying the next layer. As a result, the stability or shear resistance of the soil will be increased, premeability or water entry is decreased, and settlement of the embankment is minimized.

During earthwork operations, areas of bare soil exposed to erosion should be shaped to minimize storm runoff. Methods of control could include such devices as silt basins, sedimentation ponds, berms, and

temporary down drains, swales, ditch pits, brush barriers, and other erosion control techniques. Drainage channels should be constructed early in the grading operation. Ditches should be kept cleared, culverts unplugged and drainageways open. Drainage should never be allowed to dig its own channel. In preparing the surface for surfacing, the material should be redistributed evenly, not scraped over the edge where it may erode into the established ditch. The road grade should be established at least 5 feet above the water overflow level in wet areas and areas subject to overflow.

The procedures for erosion prevention in stabilization efforts should include soil sampling for fertility, erodibility, and texture; correlation of results with the general soils inventory; formulating mixes for fertilizing, liming, seeding, mulching, and slope dressing (generally topsoil) and provisions in design for any special problems. The desirability of topsoiling depends upon the quality of the subsoil involved and on the quantity and quality of topsoils available. Placement of topsoil over sterile subsoils will help establish vegetation and innoculate the subsoils with micro-organisms at a faster rate than under normal conditions (by dust, debris, and flowing water). Topsoil used as slope dressing over coarse or granular subsoils will help increase the moisture and nutrient relationships of the soil, reduce soil-moisture loss, and hasten vegetation establishment. Equipment to be used for seeding should be either a hydroseeder or seed drill. The use of tractor-mounted cyclone seeders is not recommended. Hand operated broadcast equipment can be used in small inaccessible areas. The best time for seeding warm-season grasses is late spring and early summer, and cool season grass should be seeded in late summer or early spring. Legumes should be seeded from mid-spring to mid-summer. Seeding in the semi-arid and arid regions should be timed to precede the period of maximum probable rainfall. Other important practices available for turf establishment are tillage and seedbed preparation and mulching.

Ditch and flume liners are also effective erosion stabilization practices. Many materials, such as sod, rock, rubble, portland concrete, asphalt concrete, plastic and others, serve as liners and should be used. Any of these liners should be used for immediate erosion control on ditch bottoms, on shoulder slopes, on low side of curves, in backslope flumes, on fill slopes at culvert ends, on bridge abutment slopes, and on other areas subject to erosion by concentrated water flows.

In rock quarry development consideration should be given to the use of the better larger pits and longer hauls, instead of several small pits, thereby minimizing the erosion problems.

Bases and surfaces should be constructed so as to prevent the entrance of excessive quantities of surface water into the base and subgrade from directly above. The base layer should be free draining to prevent capillary action and frost heave. During surfacing operations excess oil application

should be controlled to avoid stream pollution at bridge crossings, etc. Care should be exercised in picking a site for unloading the supply tankers into the distributor truck so that oil spills will not contaminate streams.

Soil around drainage structures must be protected from erosion to ensure the stability of the road structure and to prevent sediment from blocking the drainageway. Erosion in ditches can be controlled by providing a series of dams or weirs across the ditch to reduce flow velocity, so suspended matter will be deposited behind the checks. Various types of ditch checks can be made of concrete, stone, riprap, timber, steel and earth. Temporary check of straw or hay bales are also used. Points where side ditches outlet into natural drainage should be protected from erosion. Some protective measures which can be used are a vegetated sluice or chute, paving, or an outlet structure. Where the roadway is in cut interceptor ditches may be needed above the slope limits with flumes installed into the cut-slope face, or a combination of both, to prevent concentration of overland drainage from eroding the slope.

Across road structures should be placed as nearly as possible in line with the flow direction to enable a direct entrance and exit for the intercepted water. Use of short, right-angle culverts should be avoided. Use of longer and skewed culverts to follow the natural drainage pattern will result in less maintenance cost even though initial installation costs will be higher. Energy dissipators or stilling basins should be used at culvert outlets which pose an erosion problem. Bridges should have adequate subsurface investigation to provide for stable abutments and sound footing locations. Activity in the streambed should be kept to a minimum and performed during low water periods. Streambanks and protective vegetation should be conserved.

In the maintenance of roads, surface drainage can be retained by performing proper maintenance grading and shaping and by patching and filling holes and irregularities. The surface should be kept smooth, firm and free from excess loose material. Stabilization methods and dust palliatives and bituminous surface treatments should be used to minimize loss of material and to eliminate as much as possible the hazards due to dust. Surfaces can be reconditioned by scarifying and resurfacing when areas to be patched are numerous or extend over a considerable area. Bituminous surface treatments can be repaired by patching, scarifying, resealing and application of a non-skid surface treatment. Care must be exercised to avoid spillage of petroleum products during refill operations and application areas controlled to prevent soil and water contamination.

Culvert inlets should be cleared before and kept clean during the rainy season to diminish the danger of clogging and the possibility of washouts. Spur roads that outslope should be cross drained and have berms removed on the outside edge except those intentionally constructed for the protection of road grade fills. Before spring runoff begins, all ice and snow berms created on winter haul roads should be removed. Gully erosion

in waterways and ditch bottoms may be repaired by filling, shaping and lining with riprap, juted or sodded materials. Culvert ends and bridge abutment slopes which have received concentrated water flows should be stabilized and repaired. All waste materials should be deposited in stable bench or cover locations well above high water levels. In general, bridge repairs include deck, railings, expansion elements and footings, bulkheads, etc., the latter of which may require some work in the bed of a stream. As in the construction of these facilities, activities in the streams should be planned to coincide with low water. Tractors and other equipment operation in the streambed should be minimized to cause the least aggravation to the streambed and streambanks. Materials such as concrete, excess grout, form oil, etc., should not be wasted in the stream. Approach fills and banks should be stabilized to prevent erosion and trash and debris should be removed at completion of bridge site repairs.

Debris and slide material should be end-hauled and deposited on a safe bench or cover location well above the high water level. Disturbed areas should be shaped, tilled and seeded with deep-rooted legumes and grasses to hold the soil in place and fertilized and mulched or some other stabilization practice used. Gravel drains may be installed between top-soil and subsoil layers if needed to relieve water pressure and seepage.

The use of herbicides for controlling brush encroachment along road edges must be handled with care to avoid chemical drift and spillage problems which could contaminate streams. Mechanical brush cutters can be used in combination with chemical applications.

Erosion repair methods are comparable to measures taken in preventing erosion in the construction phase, however a few variations do exist. Straw or hay may be disc anchored or tacked with asphalt. Hydromulch (wood cellulose fiber pulp) should be used on high steep slopes, rock overburden areas, or areas where the wood pulp is needed to "plaster" the seed and fertilizer in place. It can be applied with a hydroseeder along with seed and fertilizer. Wood excelsior blanket is recommended on slopes steeper than $2\frac{1}{2}$:1 and longer than 25 feet. It should be used for establishing alfalfa and crown-vetch on difficult slopes and some repairing of gullies. Riprap (usually field stone) is effective for erosion control in culvert scour holes, on shoreline slopes for protection from wave action, and in lining of waterways and channels. Soil compaction and surface disturbance may be minimized by operating stabilization equipment during favorable weather and soil conditions.

Water

Development. The impact of area burning on water quality can be minimized by reducing the temperature of the burn, and by reducing over-land flow from the burned area to the stream channel. The temperature of the burn may be reduced by scattering the fuel and/or by burning under conditions which preclude high ground temperatures, such as burning

immediately after a short rain shower. Overland flow from the burned area may be reduced by completely covering the fire line, following burning, with the vegetative material that was removed during construction of the line, and by waterbars or check dams along the fire line. Filter strips of undisturbed vegetation left along the bottom of the area burn will filter some of the suspended solids from overland flow. These filter strips also reduce the velocity of flow and cause deposition of sediment before it reaches the stream.

The adverse effects of scarification on water quality may be reduced by (1) keeping machinery out of stream channels, both perennial and those that carry water during seasons of high runoff; (2) avoiding areas where slope instability will be increased by the removal of shrubs, tree stumps and roots; (3) avoiding the disruption of the normal distribution of water downslope; and (4) by scarifying along contours. Care should be taken to leave enough small plants and plant debris to protect the soil from raindrop impact. Areas of thin soils which can be easily stripped from underlying bedrock should be avoided. Soils which have a high potential for compaction by heavy equipment even during the dry season should be excluded from scarification activities. Coarser textured soils should have scarification planned for seasons when the soil moisture is low enough to reduce soil compaction. Heavy equipment should be kept out of areas with high soil moisture to avoid creation of gouges and ruts.

In baiting and chemical weed and brush control practices, the proper combination of chemicals, carrier, method of application (ground or aerial), droplet size for spray applications, and width of streamside buffer strips should be carefully evaluated to minimize the probability of accidental drift onto streams, lakes, marshes, and estuaries. Air stability is essential for aerial applications and these practices should be discontinued immediately when it appears that significant lateral drift may occur.

Methods and areas for chemical mixing, storage, loading and cleaning of equipment should be carefully selected to minimize the chance of leakage of chemicals into streams, lakes, reservoirs, marshes and estuaries. Empty chemical and carrier containers should be disposed of carefully. Monitoring of streams and bodies of water should be done prior to, during, and after chemical application to assure safe application. There are circumstances which mitigate the water quality degrading potential of the chemicals used in aerial baiting of rodents and in the treatment of aerially-disseminated seed. Poisoned wheat or oats are commonly used in baiting rodents. These baits, and tree seed, are more dense than the minute droplets which constitute the chemical sprays used in weed and brush control. Consequently, the baits and seeds are much less subject to lateral drift with moving air than are the chemical sprays, and hence less likely to miss the target area. The absence of petroleum-based carriers (commonly used with herbicides) is another circumstance mitigating the adverse impacts of baiting and seeding. Finally, aerially disseminated

baits and seeds are thinly scattered and do not cover the target area completely and uniformly, as do sprays. It follows that the volumes of chemicals used in baiting and seeding operations are comparatively small. Thus, the possibility of significantly toxic chemical concentrations reaching natural waters by direct entry or in surface runoff is slight.

The potential adverse impact of forest fertilization on the water resource may be reduced by the same precautions as with pesticides; that is, strict attention should be given to streamside buffer strips and caution in storing, loading and applying the fertilizer.

Protection. The mitigative measures that apply to chemical weed and brush control also apply to the use of insecticides, fungicides and fire retardants. The mitigative measures employed in area burning, as described earlier, also apply to backfiring. In addition, the edge of a stream or lake should be used to backstop a backfire only as a last resort. If time does not permit building a fire trail for the backfire, a road or natural break in topography may serve. Either is a preferable alternative to backfiring to the edge of natural water.

The impact of fire line construction on water quality can be reduced by creating as little surface disturbance as possible during construction, and by erosion control measures applied after the fire is controlled. Some guidelines are:

- Avoid building fire trail if control can be achieved by direct attack. A slow-moving ground fire can often be suppressed by swatting or by direct application of water.

- Lines should be built to a width no more than adequate to contain the fire, plus a realistic safety margin. Excessive construction should be avoided. If manpower is adequate and hand tools will do the job, lines should be built by hand rather than by machines.

- Lines should be located parallel to contours, if possible. Try to avoid steep gradients.

- Erosion control measures should be applied where necessary to prevent surface runoff from carrying sediment and debris into natural waters. Waterbars and check dams should be installed in fire trails to divert surface runoff and to reduce its velocity.

- The burned area should be revegetated with suitable plant species as soon as possible after the fire is out.

These considerations are particularly critical in the fragile areas found in the subalpine zones of the Montane Forest.

Cutting Practices. The adverse effects of clearcutting and seed tree cutting may be mitigated by:

- Providing streamside buffer strips of adequate width and density to reduce or eliminate sediment laden overland flow from reaching stream channels. All perennial streams and those streams which carry water during peak runoff seasons should have buffer strips. Buffer strips should contain enough trees and shrubs to provide shade for the stream and protection from the streambank. The width of the buffer strip necessary to meet these objectives should consider the slope of the ground into the stream channel; topographic shading; tree height, density, and species; stream characteristics (width, depth, and flow velocity); and the erodibility of the soil.

- Consideration of the potential for slope stability and the effect that loss of root strength will have on slope stability. Other factors that affect slope stability and which should be considered are slope gradient; thickness of the soil mantle; character of the underlying bedrock (smooth, fractured, etc.); precipitation patterns including the frequency of intense rainstorms; seasonally high ground water levels; and the inherent strength of the soil.

If these factors are critical and the success of the buffer strip appears questionable in mitigating the impact of clearcutting, other cutting practices should be considered.

Logging slash, cull trees, stumps, and other logging debris should be properly disposed of. Observations in western Oregon and Alaska have shown that logging slash left in steep ephemeral stream channels contributes to the potential for destructive debris avalanches down these channels when soils become saturated during the winter season. It is extremely important that debris be removed from these channels concurrent with logging on the clearcut area. Channel clearance should not be deferred until just before the timber sale contract is terminated.

Logging Methods. Falling timber upslope or along the contour of steep slopes will prevent felled trees from shooting downhill and into, or through, streamside buffer strips. Trees cut selectively adjacent to natural waters should be felled directionally away from the water. Logging slash and debris which enters stream channels or lakes unavoidably during falling operations should be promptly removed.

A good logging plan is an effective means of mitigating damage to natural waters. Written into the timber sale contract, the logging plan should stipulate how falling and bucking shall be done and also the logging method to be followed.

Tractor skidding should be limited to slopes with gradients of less than 35 percent regardless of the potential of the soil for compaction.

Tractor skidding should never be permitted down or across any stream channel, perennial or ephemeral. Tractor skidding should be limited to those seasons and sites where soil moisture is low enough to avoid rutting or gouging of the soil. Operators should not be permitted to clear a skid road for one or two trees; this practice results in areas crisscrossed with excessive skid roads. Since jammer yarding requires a closely spaced network of parallel roads to harvest timber from an area, adverse impacts may be reduced by confining jammer operations to existing road systems; i.e., if new roads must be constructed solely for jammer operation, an alternative logging method should be used.

In steep topography, aerial yarding systems should be used wherever feasible, particularly on areas of unstable soils. Since aerial systems often operate more efficiently with road networks differing from those which serve conventional logging systems best, road location must be coordinated with the aerial logging plan.

On productive sites and on sites with slope stability problems, landings should be located and their design specified to assure that the landing will not be overconstructed, that site productivity will not be lost by excessive sidecast, and that slope stability problems will not be created.

Transportation. Adverse impacts of road construction may be mitigated by:

- Designing the roads to minimum dimensions for the proposed use, consistent with traffic safety. If it is necessary to traverse short sections of unstable terrain, remedial measures (riprap, extra drainage, etc.) should be included in the road design.

- Care should be exercised to protect stream channels and banks by streamside buffer strips wherever possible. In the case of roads which approach stream crossings in narrow V-shaped canyons, the right-of-way clearing width may need reduction below the road to provide a vegetative strip for stream protection. The stream crossing itself should be as narrow as possible, consistent with traffic safety. The stream channel should never be used as a disposal site for excavated material from other portions of the road; often stream crossings become unacceptably wide because of this practice.

- Endhauling the excavated material if this will avoid long side-cast fills in steep terrain. Disposal sites for endhauled material should be selected with care to avoid overloading slopes and causing mass failures. Fills should be compacted if this practice will contribute to slope stability and prevent road failures.

- Installing culverts at frequent intervals to assure that the road subgrade will remain dry and stable. Drainage from culverts should never be allowed to fall on unprotected fills. Aprons should be installed on fills under culvert outfalls. Downspouts, or other suitable conductors should be used to carry culvert drainage and to dissipate the kinetic energy of this water before this is allowed to run onto natural slopes.

- Constructing and installing bridges and culverts so that the streamflow is optimum for completing the required work with minimum degradation of water quality. Activities should be planned so that heavy equipment spends the minimum amount of time in the stream channel. All activities necessary for construction and installation should be planned and executed so as to result in the minimum amount of water quality degradation.

Stabilization practices are of two general types: correction of an incipient failure of a road or slope and reduction of erodibility of a road fill, road cut, or slope. These practices generally have beneficial impacts since a successful stabilization activity maintains or improves water quality.

Aquatic Vegetation

Development. Adverse impacts of forest development actions such as mechanical brush cutting, area burning, snag felling, and chemical application of pesticides can be mitigated by leaving untreated buffer strips between treated areas and streams. Algae blooms, or growth of undesirable aquatic plants in lakes or ponds, as a result of fertilization, can be controlled by certain herbicides.

Protection. Adverse impacts of protection practices can be minimized by insuring that insecticides and other chemicals are confined to the target area; i.e., all possible techniques for minimizing drift and guarding against accidental spills should be employed. When possible, bodies of water should not be used as natural fire lines. The impacts of fire lines can be reduced by constructing them along the contour away from streams or lakes.

Cutting Practices - Logging Methods. Adverse impacts of cutting practices and logging methods on aquatic plants can also be mitigated by use of a buffer strip between the cutting area and stream. Removal of trees, slash or large debris that reach the stream, or its vicinity, during the logging operation is also an effective mitigating measure. If logs must be yarded across important perennial and intermittent streams, use of logging systems capable of suspending logs above the buffer strips; e.g., skyline, balloon, or helicopter yarding, will mitigate impacts on aquatic vegetation. Use of these yarding systems on steep slopes and erodible soils also mitigates the impact of siltation on aquatic vegetation.

Transportation. Adverse impacts of road construction on aquatic plants can also be mitigated by leaving a buffer strip of heavy or dense vegetation between roads and streams. Other effective measures include (1) location of road away from the aquatic habitat or areas of unstable soils, (2) engineering roads to prevent sidecasting, (3) water barring unsurfaced (dirt) roads, and (4) stabilizing roadside cuts and fills and culvert installation points by seeding herbaceous vegetation.

Adverse impacts from road maintenance actions can be mitigated by (1) hauling soil and debris from landslides to suitable disposal sites and (2) leaving an effective buffer strip between roadside spraying areas and the aquatic environment.

Terrestrial Vegetation

Development. Mitigation of adverse short term impacts as a result of forest development treatments that destroy existing vegetation may be achieved by confining practices to small areas of land; e.g., scarification in strips or patches, mechanical furrowing or trenching, spot burning, hand application of herbicides around individual trees, mulching, and hand clearing and cleaning. Long term impacts associated with forest development actions such as scarification, area burning, and aerial spraying of herbicides are mitigable by insuring that such actions result in environmental conditions favorable to tree regeneration on the specific site in question. This requires (1) an accurate appraisal of environmental conditions on the site prior to the action, and (2) a basis for predicting environmental consequences of the action if applied to the site. These requirements may be met by (1) classifying forest land according to plant associations, or habitat types, and forest soils, and (2) applying forest development actions to selected classes and monitoring results. In the absence of such land classification and predictive systems, mitigation is possible by limiting scarification and area burning to cool-moist sites, especially those on gentle slopes with deep, loamy soils. Adverse long term impacts from tree improvement can be avoided by adhering to statistical and genetic guidelines relative to number of trees selected per breeding unit for breeding purposes. Monoculture can be mitigated by planting several species. Long term adverse impacts from backfiring may be mitigated by planting or seeding tree species soon after the fire. Short term adverse impacts can be mitigated by seeding a variety of herbaceous plant species soon after the fire or construction of fire line.

Protection. In order to minimize the short term impact of fire lines and backfiring, as little vegetation as possible should be destroyed, without jeopardizing the objectives of the actions. When feasible, fire lines should be constructed along contour lines to minimize the indirect impact of erosion on vegetal life and growth. Disturbed areas should be artificially revegetated when natural regeneration cannot be reasonably expected in a short period of time. Most of the practices associated with protection, i.e., insect, disease and fire control, are in themselves mitigative

since they are primarily aimed at maintaining the health and vigor of the vegetal component of the forest.

Cutting Practices. Mitigation of long term adverse impacts resulting from timber harvest practices is primarily a matter of insuring that the cutting practice used is one that will result in environmental conditions favorable to tree regeneration on the specific site in question. As with forest development, land classification and a predictive system are needed to insure these results. In the absence of such information, however, long term adverse impacts may be mitigated by (1) confining clearcutting and seed tree cutting to sites where experience has shown that the practice can be expected to result in successful natural or artificial tree regeneration within two years; e.g., cool-moist sites in the Northwest Coastal sub-biome and Douglas-fir and Western Hemlock Zones of the Montane sub-biome, (2) restricting size of clearcut and seed tree cuts to approximately 40 acres or less, and (3) using selection or shelterwood cutting elsewhere; e.g., warm-dry sites in all vegetative zones, and on high elevation sites where intense light is detrimental to true firs.

Adverse impacts of windthrown trees along edges of clearcuts and throughout seed tree and shelterwood areas can be mitigated by early removal of hazardous concentrations. Windthrow in shelterwood cutting areas can be controlled by cutting small amounts of standing timber at frequent intervals rather than doing the opposite.

Logging Methods. Adverse short term impacts resulting from destruction of vegetation by logging methods can be mitigated by using only those methods that result in minimum disturbance to understory, shrub and herbaceous layers, e.g., skyline, balloon and helicopter yarding. However, mitigation of long term adverse impacts resulting from the use of various logging methods, is, like development and cutting practices, a matter of insuring that resulting environmental conditions are favorable to tree regeneration on the specific site in question. Requirements are likewise the same; i.e., land classification and a predictive system. In the absence of such information, however, adverse long term impacts may be mitigated by using logging methods that disturb herbaceous and shrub layers (tractor or high-lead yarding) whenever (1) such layers are well developed beneath the overstory and do not contain adequate tree regeneration, (2) use of forest development actions to destroy vegetation is impractical; e.g., steep topography that precludes scarification, or fire hazard precludes area burning, and when soil compaction or erosion will not occur.

Mitigation of adverse long term impacts resulting from use of minimum disturbance logging methods, i.e., skyline, balloon, and helicopter yarding, is effectively accomplished by forest development actions that destroy vegetation, i.e., scarification, area burning, mechanical brush cutting, and aerial application of herbicides. Where these measures are not feasible due to adverse impacts on other elements of the environment, forest

development actions such as hand clearing and cleaning, hand application of herbicides, and use of shade tolerant species of trees in tree planting may also mitigate long term impacts.

Transportation. In general, some short and long term adverse impacts caused by road construction can be mitigated by locating and engineering roads so as to avoid sidecasting where possible. Specific recommendations for mitigating adverse impacts on soil are also applicable to mitigation of adverse impacts on vegetation.

Aquatic Animals

Development. Throughout the Coniferous Forest Biome mitigation of adverse impacts caused by heavy equipment in scarification, and mechanical brush cutting can be accomplished by (1) confining these practices to conditions that preclude soil compaction and erosion, e.g., gentle slopes with deep non-erodible, dry soils, (2) using an effective vegetative buffer between treated areas and streams, (3) water-barring and revegetating spur roads constructed during the operation, and (4) preventing machinery from crossing streams except over bridges or culverts.

Adverse impacts of chemical weed control can be mitigated by avoiding direct application to standing or running water by establishing vegetative buffers between streams and treated area, especially where non-hand application methods are used. The risk of accidental spillage of pesticides and petroleum products into streams can be minimized by selecting safe routes for transport vehicles to travel and safe places to load and fuel aircraft.

Impacts can also be reduced by confining application to the target area and preventing drift of spray into adjacent areas. Drift can be minimized by spraying only when air is calm and using (1) helicopters instead of fixed-wing aircraft, (2) invert emulsions where technically feasible instead of "conventional" methods, and (3) spray orifices that produce droplets least prone to drift by wind. Pilots thoroughly familiar with the area are least likely to make mistakes and spray off-target areas.

Adverse impacts of fertilization can be mitigated by confining application to watersheds that do not drain into lakes or reservoirs and by avoiding application to standing or running water. Use of buffer strips is an effective mitigating measure; like chemical weed control, mitigation requires insurance against accidental spillage into streams.

The use of an effective buffer strip between streams and the burned areas is also an important mitigative measure for area burning. Another means by which to avoid adverse impacts to aquatic wildlife is to confine area burning to gentle slopes and soils that are not erodible. Substitution of spot burning or chipping of slash is also effective mitigation if done away from streams and behind effective buffer strips.

Adverse impacts of baiting and seeding (where seeds are treated with toxic chemical repellents) can be mitigated by: (1) selecting chemicals least toxic to aquatic wildlife, including insects, (2) avoiding application over water, (3) using hand application methods where possible, (4) using helicopters instead of fixed-wing aircraft if aerial application is essential, and (5) using a buffer zone between the aquatic habitat and treatment area.

Other possible mitigative measures include: (1) avoiding fencing across streams that support fish so as to preclude blockage by drifting debris, (2) avoiding snag felling in buffer areas, or if it is necessary, fall them away from streams, and (3) avoiding thinning or pruning immediately adjacent to streams.

Protection. The most effective mitigative measure for adverse impacts associated with use of pesticides is to restrict control activities to use of biological methods; i.e., predators and viruses. Where insecticides are used some effective mitigative measures include: (1) selection of insecticide and rate of application least toxic to aquatic wildlife, including insects, (2) use of buffer zones between aquatic habitats and treatment area, (3) confinement of treatment to treatment area by using helicopters instead of fixed-wing aircraft, spraying only when air is calm and using only pilots familiar with the treatment area, (4) using latest technology for producing a spray that tends to fall rather than drift in air currents, and (5) as with chemical weed control, select transportation routes and loading sites to preclude spillage of insecticide into aquatic habitat. Precautionary measures similar to use of insecticides and chemical weed control may be used to mitigate impacts from use of fire retardants.

Cutting Practices. To minimize impacts on aquatic wildlife the cutting practice that is least destructive to terrestrial vegetation and soil should be used; i.e., selection cutting should be considered first followed by shelterwood, seed tree and clearcutting. Regardless of the cutting practice used, however, adverse impacts can be effectively mitigated by leaving buffer zones of effective vegetation between the aquatic habitat and cutting area so as to prevent increases in stream temperature, reduce sediment intake of streams, protect existing stabilized streambanks and retain character of the bottom. Impacts can be further mitigated by not falling trees into streams.

Logging Methods. To mitigate adverse impacts, the logging method least destructive to soil and terrestrial vegetation (i.e., aerial methods such as skyline, balloon or helicopter yarding) should be used, especially on steep slopes and shallow, or erodible soils. A wide buffer zone of standing trees left along the aquatic habitat, may prevent up-slope trees from crashing into the stream during the falling operation. Trees nearer the stream can be felled last, possibly away from the buffer zone and stream. Streams can be protected from mud and siltation to some degree

by prohibiting yarding during periods of heavy rainfall. Logging debris that finds its way into streams or the immediate vicinity of streams should be considered for removal as a mitigating measure against stream blockage during periods of high water.

Other potential measures to mitigate adverse impacts on aquatic wildlife include: (1) stabilization after logging, of all disturbed areas, especially skid trails and spur roads, with fast growing herbaceous plant species of good soil holding characteristics, (2) removal of all temporary structures from streams, (3) careful removal of fills at stream crossing rather than allow high water to carry soil away, and (4) use of sediment and debris traps.

Transportation. Adverse impacts associated with road construction and maintenance can be mitigated by the following measures:

- Locate roads away from the aquatic habitat; use suitable vegetative buffer for roads that have to be near streams.

- Locate and design roads so as to prevent sidecasting of soil, rocks and debris.

- Do not obtain road gravel from streams.

- Do not make stream channel changes.

- Riprap unstable banks along streams.

- Stabilize cuts and fills with drainage structures and fast growing herbaceous vegetation with good soil holding characteristics.

- Locate rock crushing and washing sites away from streams.

- Use road surfacing materials that will not erode during wet weather.

- Spill water from drainage culverts on stabilized areas only.

- Use adequate sized culverts and bridges (consider possibility of future timber removal above culvert or bridge site and impact on anticipated flows). Design stream crossings to provide upstream fish passage for migratory species.

- Do no construction work during periods of heavy rainfall.

- Deposit soil and debris from landslides and endhaul in locations where erosion into streams will not occur.

- Leave a buffer of vegetation between roadside spray areas and the aquatic habitat.

Terrestrial Animals

Development. Loss of habitat due to tree improvement, and other practices that materially shorten the growth cycle of conifers, can be compensated for by the proper spacing of cuttings, size of cuttings, and timing of cuts to assure a diversity of regenerative age classes.

To mitigate adverse impacts of scarification, mechanical brush cutting, burning and chemical weed control, surface cover destruction should be restricted to small areas. Brush removal should be avoided on big game winter ranges, calving and fawning sites.

While regulations prohibit the general use of poisons such as endrin, strychnine, and "1080" for rodent baiting and tree seed treatment, clearance has been received for the use of strychnined-salt blocks for porcupine control. These blocks should be placed in specially designed metal bait stations. Any other approved baits should be placed underground, in runways, or in other protected sites where a degree of protection can be provided non-target species. Carcasses of poisoned animals may be burned to protect carrion-feeding predators from effects of secondary poisoning.

Adverse impacts of baiting can be totally avoided by using the alternative of fencing and screening to protect conifers from seed and seedling destroying animals. Current research projects are designed to (1) find a chemical seed protectant as an alternative to endrin, and (2) protect tree seed by masking its odor.

Adverse impacts of fencing can be mitigated by making exclosures completely deer and elk-tight to preclude their entry and entrapment; the smaller the exclosure, the less chance of larger animals gaining entry. Another mitigative measure is to avoid use of fences on big game migration routes, calving or fawning areas, or in sites of intensive hunting. Since antlered animals are easily entangled and killed in nylon mesh, mitigation can be achieved through use of conventional wire fences.

Mitigation of adverse impacts from snag felling can be achieved by reserving high quality snags (with regard to wildlife use) in selected locations. Eagle and osprey nest tree preservation sites should also include adjacent dead trees and snags used for perching on by both young and adults. Preservation of snags, flat tops, spike tops and other dead and dying trees used by wildlife considered endangered should receive highest consideration. If important snags or dead trees cannot be saved, the girdling of some live trees on the site for future wildlife use can be used as a mitigating measure.

Adverse impacts of precommercial thinning and pruning may be mitigated by confining the actions to the time of year when human activity on the site will not preclude reproduction or wintering activities.

Protection. Adverse impacts of protection practices can be minimized by insuring that insecticides and other chemicals are confined to the target area; i.e., all possible techniques for minimizing drift and guarding against accidental spills should be employed. Before any control of insects and disease is initiated, a survey of the area should be conducted to determine what non-target wildlife species are present, and how they would be affected by proposed control methods.

Cutting Practices. To avoid adverse impacts to the greatest number of wildlife species, cutting, particularly clearcutting, should be confined to small, scattered tracts ranging from 15 to 30 acres in size so as to produce the greatest "edge" effect in any general area. To avoid the short term impact of harvesting on nesting and wintering wildlife, falling and bucking, and yarding operations should be done at times other than the nesting season or months of severe winter weather.

Logging Methods. Areas denuded of vegetation as a result of tractor, high-lead or other ground systems can be seeded to grass-legume-browse species best suited to a variety of wildlife in critical food shortage areas.

Transportation. Adverse impacts of transportation on terrestrial wildlife may be mitigated by:

- Avoiding road construction during the nesting season.
- Avoiding big game winter range or closing roads to travel during winter.
- Closing spur roads when not necessary for timber management.
- Leaving vegetal screening cover along main roads through cutting areas.
- Keeping rights-of-way clear of vegetation along paved roads to minimize opportunity for wildlife destruction by fast moving vehicles; use unpalatable species of vegetation for roadside stabilization and post signs warning of presence of wildlife.
- Locating and engineering roads to avoid sidecasting soil, rocks and debris, etc., down steep sideslopes.
- Designing cut banks along steep sideslopes to allow unrestricted wildlife travel.

Ecological Interrelationships

The mitigative measures individually described for each component of the environment in this section represent, collectively, the actions which

might be taken to maintain stable ecological interrelationships. Consequently, they are not restated in this part.

Many practices identified as part of the program are in themselves mitigative in preventing or restoring any ecological imbalances or damage incurred in the course of carrying out disruptive practices. Mitigative measures include such practices as seeding, planting, chipping, fencing, mulching, protection, etc. Usually, the disruptive practices are those associated with the cutting, logging and transportation phases of the program. Mitigation is largely a matter of where, when and how these practices are carried out.

The effectiveness of mitigative measures generally would be most critical in preserving the natural balance in fragile areas of low productivity, and in valuable aquatic ecosystems.

Human Values

At the beginning of this statement, planning was emphasized as one of the best tools for mitigating conflicts between timber management activities and other land uses. Most of the unmitigated impacts discussed in the preceding part can be prevented or minimized with proper land use planning.

For instance, land use plans prepared by BLM personnel identify resource values and resolve conflicts on the public lands. Where conflicts exist between two or more competing uses, they are resolved through (1) adjustments in the timing or season of occurrence between conflicting uses, (2) adjustments in the relative intensity or level of use between uses, and (3) initiation of practices on the ground designed to minimize or avoid conflicts. If none of these is successful, then one or more conflicting uses must be eliminated for that planning area.

The resolution of conflicts between land uses on the public lands and on adjacent non-Federal land can be accomplished through coordination of planning between BLM and local government agencies. Where local government planning is absent or inadequately enforced, these conflicts are not easily resolved. Land uses incompatible with timber management such as recreation subdivisions or ski lodges, developed on adjacent private lands, may force curtailment of some timber management activities.

In addition to conflicts of land use, conflicts between land uses and resources must also be identified and resolved in land use plans. Timber management activities damaging to one or more resource values should be modified to reduce or eliminate adverse impacts.

In the following discussion on mitigation of impacts associated with timber management, reference will be made to land use planning as a mitigative measure where appropriate.

Health and Safety. Where human inhabitants are living on or near BLM lands where chemicals are to be used to control or remove brush and weeds, adverse effect on the health of these individuals can be avoided by:

- Using only approved chemicals, applied at the minimum rate necessary to do the job.

- In the case of occupants on or in the immediate vicinity of the lands to be treated, timely notification of the intent to conduct aerial spraying and the date and time that it will be done.

- Using helicopter instead of fixed-wing aircraft to minimize the risk of off-target application.

- Applying chemicals only when the wind is calm.

Chemicals should not be allowed to enter streams and open bodies of water.

Ill effects on inhabitants caused by smoke from slash burning can be mitigated by burning on days when atmospheric conditions favor rapid rise and dispersal of smoke. All such burning should be done in accordance with a smoke management plan. Quarrying and rock crushing activities should not take place where inhabitants will be subjected to clouds of dust. Alternate sources of quarry material and crushing sites away from inhabitants should be utilized.

Safety hazards associated with log trucks and the motoring public can be mitigated by proper road design, avoidance of blind curves, providing adequate turnouts for passing, and use of warning signs.

Accidents and injuries involving timber harvesting and management activities can be reduced by ensuring that employees receive adequate safety training, that they are thoroughly trained in their jobs, that they wear required safety equipment, and that they use the proper equipment, maintained in a good state of repair.

Mineral Development. The objections of prospectors and mining claimants to timber management practices can sometimes be overcome by personal contact. Assurance can be given that the proposed action involves only the timber resource, with no real infringement of mineral exploration or development rights.

Wilderness. Although BLM is presently unrestricted by any mandate for preserving roadless areas in western Oregon, commercial forest lands unique in character should be identified and considered for withdrawal as natural areas.

Recreation. Developed and potential recreation sites should be excluded from commercial timber production and screened by permanent vegetative buffer strips, with trees reserved from cutting. Sometimes removal of danger trees may be necessary for user safety; however, logging on recreation sites and adjacent areas should be conducted during the period of least use, to the extent feasible. Sources of potable water supplying recreation sites should be permanently protected from possible contamination by any timber management practices. Roads providing access to recreation sites should be dust-proofed and built to standards that permit both car and truck traffic to move safely.

Natural waters providing recreation to fishermen, boaters and swimmers should be safeguarded from sedimentation, scouring and mass soil movement by adequate vegetative buffer strips and proper road location and stabilization. Clearcutting on unstable soils and steep ground upslope from such waters should be avoided.

Since wildlife makes a major contribution to the quality of forest recreation, wildlife habitat must be considered in planning for timber harvest. Adequate escape cover, bedgrounds, elk calving grounds, etc., should be reserved from cutting or subjected to special cutting practices in order to perpetuate resident species. Den trees or nesting trees may be reserved and seasonal restrictions set on logging operations to avoid harassment of wildlife during critical periods when the young are born and reared.

Areas subject to heavy recreational use may require the application of special cutting practices if recreational values are to be preserved. Cutting methods that detract least from a natural appearance should be used wherever possible. Continuous canopy management may perpetuate quality recreation in such areas. This is a system of modified shelterwood cutting wherein final removal of the overstory is deferred until regeneration in the understory is large enough to present a forest-like appearance.

Mitigation of adverse effects on recreation should also include repairs or reconstruction of any recreational facilities or improvements damaged during timber management operations. It is also essential that all logging litter and junk on operating areas be removed and disposed of properly.

Grazing. As in the case of mineral development, good communication with livestock producers can do much to alleviate the ill effects of conflicts between timber production and grazing.

Agriculture. Adverse impacts caused by chemical weed and brush control drifting from forest land onto nearby crop land can be mitigated by using helicopter aerial application instead of fixed-wing aircraft and spraying only on calm days.

Impacts on downstream irrigation reservoirs and facilities caused by siltation from soil erosion can be mitigated by avoiding development and harvesting practices that disturb fragile soils. As an additional precaution buffer strips of vegetation should be left along streambanks to help hold and prevent soil from washing into streams.

Transportation systems should be planned to cause the least disturbance to soils; the road construction should be avoided on steep, fragile soils.

Commercial, Residential and Industrial. Conflicts between timber management practices and adjacent residential and commercial land uses can best be mitigated by preventing them from occurring. Coordination of land use plans with the planning and zoning of local governments can (1) advise BLM managers of the likelihood of land uses being introduced on adjacent private lands that would conflict with timber management objectives, and (2) advise local governments of the timber management objectives thus allowing them opportunity to plan and zone intermingled private lands.

Local Government and Public Services. Accidental disruption of utility services caused by timber management practices can largely be precluded through proper planning. Land use plans can (1) inform public service companies of resource areas, including timber, that should be avoided in planning utility route locations, and (2) identify and designate corridors on the public lands where utilities can be placed with minimal land use conflicts.

Adverse impacts on local and state highways and bridges can be mitigated to some extent through good coordination with county and state highway departments.

Aesthetics. Most people appreciate natural beauty. Many individuals pursue geology, archeology, history, etc., as hobbies or avocations. The adverse impacts of timber management actions on these areas of interest may be alleviated by various means.

A primary mitigating influence is the Bureau Planning System (described in Section I of the Statement), whereby areas of outstanding scenic quality or human interest value may be excluded from the timber management program.

Visual impacts may be reduced by several measures. The appearance of smoke in the atmosphere from area and spot burning of slash may be minimized by smoke management technology. This involves the coordinated effort of meteorologists and public and private forestry agencies to integrate burning schedules with weather reports so as to produce rapid fuel combustion and quick dispersal of smoke into the upper atmosphere. Alternative slash disposal measures which create no smoke may be feasible; e.g., chipping or burying of slash.

Atmospheric dust arising from road construction operations may be somewhat reduced by watering of subgrades during blading and surfacing operations. Dust from log hauling by truck can be abated by oiling roads or surfacing them with bituminous material or macadam. Hard surfacing of forest mainline roads is an increasing practice. Periodic application of water or waste sulfite liquor to dirt or gravel-surfaced roads reduces the dust problem.

The visual impact of cutting practices and logging operations can be mitigated by various means. Special cutting practices which retain some of the forest overstory are much less obvious than clearcutting. These practices are feasible in many situations, but not in all. One concept employs a system of modified shelterwood cutting which defers final removal of the forest overstory (dominant trees) until understory regeneration is large enough to present a forest-like appearance.

Clear, cool streams of high water quality are a characteristic of the biome. The visual impact of turbid, muddy or debris-filled streams creates a feeling of disgust to the viewer. Design all operations to protect the water quality and stay within State standards of turbidity.

The adverse psychological effects created by highly visible timber management activities can be greatly reduced by skillful, perceptive use of landscape management techniques. Landscape management is the art and science of planning and administering the utilization of natural resources in such ways that the resulting effects on the visual resource maintain or enhance man's psychological welfare.

Landscape management techniques have various applications. On gentle terrain, a roadside buffer strip of uncut trees and undisturbed ground cover may be reserved to screen aesthetically unpleasant activity in foreground distance and middle ground distance zones from the view of sightseers. Where clearcut areas will be visible in middle ground distance and background distance zones, negative psychological effects can be mitigated by avoiding straight cutting edges and square rectangular shapes, by locating cutting lines along contours so as to conform with topography, by blending cutting lines into natural vegetative features, by keeping middle ground clearcuts small, etc. Landscape management can also do much to reduce the unsightliness of scars on the landscape and unnatural openings created by road construction.

Cleanup of unsightly litter resulting from timber management operations can be required by the provisions of contracts for development projects and for timber sales.

Probably a good deal of unfavorable public reaction to the aesthetic impacts of timber management exists because some people do not understand natural processes. If they can learn, for example, that the visual impact

of a recent clearcutting is relatively temporary because the managed forest is self-renewing, much ill feeling might be dispelled. The various news media offer some opportunities in this regard. So do outdoor classrooms for children of school age.

Sound, Odor, and Mood. Little can be done about odors emanating from internal combustion engines. The smells of smoke from burning slash and of dust from various operations can be mitigated to some extent by measures described under Aesthetics.

The high noise levels produced by the engines of logging and construction equipment could probably be reduced by improved muffler systems, but so far as is known, there has been no effort in this direction.

Geology. Identification and designation of unique geologic formations in land use plans is the foremost mitigative measure available to preserve their human interest values. Timber management activities should be planned and executed to prevent damage to such formations. Roads should be kept away from them and clearcutting should not be allowed nearby.

Archeology. No timber management activities that would disturb or otherwise affect archeological sites should be allowed in their vicinity. Roads should be kept away from undisturbed sites. New finds should be reported to the appropriate Federal and State agency having responsibility for investigating and evaluating archeological sites. Contractors and their employees should be made aware of known sites in their area of operation.

History. Timber management activities in the vicinity of historical sites should be planned and conducted to avoid both physical and visual damage. Roads should detour around or away from them. Contractors and their employees should be instructed to avoid damaging historic sites.

C. Recommendations for Mitigation of Environmental Impacts

It is impractical to attempt to compile a list of recommended mitigative measures, given the variability of the micro-sites to which the management measures are applied. For any specific action, the case file reflects the mitigation efforts deemed appropriate for that specific case. By understanding this relationship, the reader can then consider the appropriate residual impacts.

D. Residual Impacts

This section discusses the adverse impacts which can be expected to remain after a reasonable effort has been exerted to apply all applicable, feasible mitigative measures described in the previous section. It comprises a compilation of unavoidable impacts not subject to mitigation and the residual adverse effects likely to remain despite mitigative efforts. This discussion does not take into consideration those instances where potential land use or resource programs conflict and are irreconcilable, resulting in a management decision to classify a particular area for a single use or selected uses.

Depending upon the nature of the classification, the unavoidable impacts of timber management practices set forth in this section may be either diminished or increased. This section, as do the following sections, addresses itself to the identification of the impacts of the general timber management program throughout the entire forest. In this sense, the unmitigated impacts described in a previous section can be of assistance to management in evaluating alternatives prior to rendering a land use or resource decision where irreconcilable differences do exist.

This analysis is necessarily subjective to a degree. In the same way it was decided to use a relatively low level of performance in dealing with unmitigated impacts, a judgment factor must be imposed here also to estimate the effectiveness of mitigation measures based on assumed thoroughness in execution and probability of favorable technical results. It has been assumed that prescribed mitigative procedures will be used and enforced, and furthermore, that the contractor or private operator will be cooperative.

In some of the parts that follow, the development, protection, cutting practices, logging methods and transportation phases have been combined since their continued separation in this section, and subsequent sections, is not as meaningful or as helpful to the reader as in previous sections.

Air

Development. Despite improved smoke management technology, there will continue to be occasions when smoke from burning forest fuels will find its way into the lower atmosphere over population centers. These occurrences will be significant only as a temporary nuisance. Inevitably, as long as prescribed fire is used, there will be misapplications due to human error and accidents of nature. Some brush fields will be created and some forest sites made temporarily unproductive by micro-climatic changes.

Protection. The discussion of prescribed burning (in preceding subsection) applies to the unavoidable impacts of backfiring on local climates.

Cutting Practices and Logging Operations. Cutting practices can have some unavoidable adverse impacts on local climates. It may be necessary to clearcut insect-infested timber on a severe site, and to burn the slash to forestall an epidemic. The resulting exposure may create micro-climatic conditions which make regeneration of the site very difficult. As another example, a cutting practice used successfully in the past may be applied to obtain natural regeneration. Deviation of the general climate from its normal pattern for a year or two after cutting may cause micro-climatic changes which inhibit regeneration and favor the invasion of the site by brush.

Short term air pollution by engine emissions and dust during logging operations is unavoidable but relatively insignificant.

Transportation. The unavoidable adverse impacts of road construction and log hauling on local climate are relatively minor. Air quality will be temporarily degraded by engine emissions and dust will sometimes be a nuisance in the vicinity of road construction operations and along logging roads. Micro-climates will be permanently modified in limited areas on road rights-of-way.

Land

Development. Development practices, such as scarification, mechanical-trenching and furrowing, area burning, spot burning and hand clearing and cleaning will result in some localized erosion due to vegetal destruction.

Protection. Fire line construction and backfiring can be expected to result in an indeterminable amount of erosion. In most of the fragile areas this amount will reach significant proportions.

Cutting Practices and Logging Methods. Some erosion and/or soil compaction will occur regardless of the cutting practice or logging method used, particularly on steep terrain.

Transportation. Landslides and gravitational erosion cannot be completely eliminated and will periodically occur along roads as a result of freeze-thaw actions and from the water saturation of slopes during the rainy and winter seasons. Severe rainstorms will cause blockages of drainage facilities resulting in soil movement and loss. Some streambed disturbance cannot be avoided during bridge construction and culvert installation. Accidental spills of chemicals, oil, etc., will occur but their impact can be expected to be minimal.

Water

Development. Heavy rains immediately after a prescribed burn, before any or all rehabilitation measures can be accomplished or can take effect, may cause suspended sediment to be carried into streams even through a wide

vegetative filter strip. Heavy rains may also cause an increase in slope instability with a large debris avalanche or soil slump resulting. In such events, vegetative filter strips and buffer strips of timber and shrubs may be completely ineffective in preventing masses of debris and soil from reaching and damaging a stream. Unforeseen shifts in wind during chemical weed and brush control can cause drift of chemical pesticides onto streams and bodies of water.

Protection. The unavoidable impacts of applying insecticides, retardants, etc., and backfiring are the same as chemical weed and brush control and burning, respectively, as described under Development. The construction of a fire line on a going fire, requiring quick control may not allow time for thorough planning and best location of fire lines. The same urgency may dictate that fire trails be built by heavy equipment, with resulting degradation of water quality. During severe fire weather, several fires burning concurrently or at short time intervals may preclude the use of limited manpower in applying erosion control measures promptly to fire lines.

Cutting Practices. Research has found that the removal of vegetation from clearcuts in western Oregon can cause changes in the seasonal distribution of runoff and in the magnitude of some late fall peak flows. The result of clearcutting in this area has been to increase streamflow during the heavy rainfall period, November through April. This research has also shown that if heavy fall rains follow a dry fall period, the peak streamflow may be significantly higher from clearcut areas. On sites with unstable soils, this increased streamflow or occasional higher peakflow could conceivably initiate a cycle of stream erosion and slope failures with a significant decrease in water quality.

Logging Methods. Felled trees may unavoidably slide down steep slopes and into or through streamside buffer strips, causing localized soil erosion or disturbance of the vegetation along the streambank. Some soil compaction is inevitable on any area that is tractor logged. Temporary, localized soil disturbance and erosion can be expected in most logged areas regardless of the method employed.

Transportation. Streams near or adjacent to road construction projects can be expected to carry additional suspended sediment during the life of the project. This sediment may be derived from excavation, embankment and bridge construction, culvert installation, and surface runoff from culverts and road and fill surfaces. Subsequently, culverts, slopes and surfaces may fail from water saturation, heavy loading or from blockage by debris, following heavy rains or melt off, causing erosion or drainage to bypass regular channels and carry sediment in surface runoff.

Aquatic Vegetation

Although many recommended mitigative measures reduce soil erosion, the natural rate of sedimentation of aquatic ecosystems is normally

accelerated by many timber management actions. Increased sedimentation shortens the natural life of lakes, ponds, marshes and estuaries by filling their basins, thereby speeding up plant succession and eventual conversion to land masses. Aquatic plants are ultimately replaced by terrestrial vegetation in this process which usually requires centuries under normal conditions but can occur in relatively few years if substantial increases in sedimentation occur.

Terrestrial Vegetation

Significant short term adverse impacts (i.e., immediate and extensive destruction of existing vegetation) will frequently be accepted as a cost of avoiding adverse long term impacts (i.e., excessive delay in regenerating and developing a new forest similar to the one removed). The classic example will occur most frequently in the Northwest Coastal sub-biome where clear-cutting, scarification, aerial spraying of herbicides and area burning may be used to insure timely replacement of a well stocked Douglas-fir forest as opposed to vegetative cover of shrubs, hardwood trees and scattered hemlock or Sitka spruce. Thus there is often a conflict between the mitigation of long term and short term impacts; when this occurs attention is usually given to long term impacts.

Adverse long term impacts may also occur anywhere within the two sub-biomes due to accidental misapplication of certain actions in the face of unseen environmental conditions. An example is likely to be failure of tree regeneration amid flourishing herbaceous or non-coniferous woody vegetation following application of normally "safe" actions such as (1) shelterwood cutting in the Montane sub-biome, and (2) clearcutting on relatively cool-moist sites in the Northwest Coastal sub-biome and certain vegetative zones of the Montane sub-biome.

Aquatic Animals

Despite implementation of recommended mitigative measures, some short term disruptions of the aquatic habitats and subsequent damage to aquatic wildlife will occur as a result of accidental stream blockages, soil erosion, etc. Mainline roads will cause a long term unavoidable impact due to the presence of people and the associated disruption and destruction of wildlife.

Terrestrial Animals

The implementation of many mitigative measures will serve only to reduce, and cannot entirely avoid, short term adverse impacts on terrestrial wildlife. Individual animals, for example, will be killed or displaced by timber management activities such as scarification, mechanical brush cutting, area burning, falling and bucking, yarding and road construction. Mainline roads will cause a long term unavoidable impact due to the presence of people and the associated disruption and destruction of wildlife.

Ecological Interrelationships

Most practices will alter the appearance of the ecosystem and temporarily disrupt the balanced relationships between its components, particularly those practices that involve vegetal destruction or removal, and soil movement. In these instances the nutrient cycle, hydrologic cycle, and energy flow will be interrupted until the impacted area is revegetated and the ground stabilized. Fragile ecosystems, where productivity is low and the natural balance delicate, will be most severely impacted and slowest to recover, particularly where the ecological equilibrium has already been impaired by prior human activity. In the case of the areas occupied by roads, ecological relationships will never be restored during the life of the facility.

It can be safely assumed that almost any action of man that affects the biotic community and/or the physical environment will impact the ecosystem to some degree regardless of the mitigative measures that are brought to bear. However, with the proper application of timber management practices, the impact should be minimal in terms of the basic processes of the ecosystem and of relatively short duration.

Human Values

Most of the adverse human and land use impacts caused by timber management activities can be mitigated, or avoided, through planning and the employment of mitigative measures. Some, however, cannot be mitigated entirely, and these become residual impacts.

Health and Safety. The primary unavoidable impact involves workers in timber related jobs. Despite safety programs and safety conscienceness of employees, accidents that cause injury and occasionally deaths are going to happen. Accidents involving the motoring public and log trucks and other logging equipment will occur as long as simultaneous use is made of the road.

There will also be occasions when smoke from slash fires drifts over inhabitants despite mitigative measures and precautions; however, no significant impacts are expected.

Mineral Development. There are no unavoidable adverse impacts of significance.

Wilderness. The timber management program poses no threat of real damage to the wilderness values of the Northwest Coastal and Montane subbiomes; providing unique aesthetic and natural attributes are recognized where they exist.

Recreation. The timber management program will have some unavoidable adverse impacts on various facets of recreation. Natural waters which provide fishing, boating and swimming opportunities may be muddied or

invaded by debris carried downslope from logged areas in surface water runoff. Some cutting practices, and prescribed burning, may eliminate recreation from an area for a time. There will be occasional damage to some recreational facilities and improvements. Smoke, noise, and dust will cause local discomfort to outdoorsmen.

Grazing. The nation's growing consumption of forest products may require eventual reductions in the use of some forest lands for grazing of domestic livestock. On commercial forest land of high site quality, grazing often causes unacceptable damage to timber values. This means that grazing may eventually be excluded from some portions of the Coniferous Forest Biome. The adverse economic effect of the anticipated grazing reduction will be insignificant nationally. However, individual livestock producers may be significantly affected.

Agriculture. Barring accidents and "acts of God," there should be no unavoidable impacts to agriculture, either by herbicide spray drift onto agricultural crops or by siltation of reservoirs and irrigation works.

Commercial, Residential and Industrial. There should be no unavoidable impacts on nearby residential or commercial enterprises. An exception may occur in cases where unsuitable and incompatible land uses, such as an unplanned subdivision, encroach on a management area and, upon considered evaluation, it is determined that restriction of timber management activities in deference to the encroachment would not be in the best interests of the public.

Local Government and Public Services. There should be no unavoidable impacts on public services, with the exception of an occasional accidental interruption of a utility located in a timber management area.

There may be unavoidable impacts on some local and state departments such as highway maintenance, patrol, etc., causing an increase in their workload.

Aesthetics. The timber management program will continue to cause some impairment of aesthetic values, even when all feasible mitigating measures are carefully applied. Atmospheric smoke from prescribed burning will be visible at times, as will dust from logging and road construction operations, and from truck hauling of logs. Clearcuttings and heavy partial cuttings will detract from the natural appearance of the forest. So will unsightly road cuts and fills, and the occasional massive soil movements which will occur as results of some accidental or ill-advised construction and logging operations. The smells and sounds of timber management operations will also continue to affect the moods of forest visitors in various ways. A road constructed adjacent to a stream may forever be an impact on the beauty of the stream.

Geology. There should be no unavoidable adverse impacts on geologic features of human interest. These can be readily recognized if identified during development of land use plans.

Archeology. Because it is often difficult to locate archeological sites or for the untrained eye to recognize some sites, there may be an occasional site destroyed, even though professional assistance is utilized.

History. There should be no unavoidable impact on historical values since those of interest can be identified and the necessary precautions taken.

E. Relationship Between Short Term Use and Long Term Productivity

The timber management program is, of course, not a short term use but a continuous use which involves different actions being applied to different parts of the forest over time. Most of the individual practices carried out on a particular area do imply a short term use. However, this section is not concerned with how short term use is defined but rather with long term productivity. Since forest productivity extends beyond commercial timber to include wildlife, water, recreation, etc., it must be reviewed in a manner that includes all resources and uses.

The time frame to be used in this statement in identifying the impact on these values is relatively long (100 years), in order to equate the program with the approximate rotational period of tree harvest. This long range view is necessary because trees represent the predominant life form of the forest and the primary productivity of the biotic community.

Air

In general, the practices associated with the timber management program do not affect the climate or air as they relate to the long term productivity of the forest.

Land

The construction of an extensive network of roads, or other management practices that expose large surface areas to erosion or mass soil movement, decrease future productivity on the affected areas by removing or destroying the soil layer upon which new growth is dependent.

While some development practices may have a short term detrimental impact on localized areas, most practices will either increase or not affect long term productivity. The removal of timber by periodic harvesting may eventually lead to depletion of soil nutrients. The area occupied by permanent roads will not be productive during the life of the facility. Even where reclamation of surplus roads is undertaken, productivity will be permanently reduced where extensive cuts and fills were made. In all probability, the full productivity of quarry sites will not be restored despite the mitigative measures taken. Decreased long term productivity as result of any management practice that significantly effects vegetal and ground cover, such as fire lines, may be expected.

Water

In those areas where snowmelt forms a significant portion of the seasonal runoff, the increased snowpack which occurs after cutting, particularly clearcutting, is a definite benefit by increasing water productivity. Where slopes and stream channels are stable, this increased

runoff has no adverse effects and suspended sediment concentrations will remain relatively stable. Periodic erosion along roadways resulting from seasonal rains and storms will have a minimal impact on the productivity of the aquatic ecosystem.

Aquatic Vegetation

Timber management practices generally have a minor detrimental effect on the long term productivity of aquatic plants. The productivity of plants in standing water habitat may be initially increased for a relatively short period of years because of favorable habitat changes caused by accelerated sedimentation. However, long term productivity can be diminished because the natural life of the habitat is reduced by continual, long term sedimentation.

Terrestrial Vegetation

The short term use of land for timber harvest will generally have little, if any, adverse impact on long term vegetative productivity provided the necessary mitigative measures are carried out. Vegetation is a renewable resource, capable of reestablishment on most areas that are denuded during timber harvest and forest development actions. Through natural revegetation and man-controlled forest development actions, the productivity of the site can be maintained. Timber yield especially, can be increased through timber management practices, i.e., development, protection, commercial thinnings, mortality salvage and the timely harvest of the crop prior to the period of natural declining growth and general stand deterioration.

Aquatic Animals

Short term use of land for timber production will not endanger long term productivity of aquatic wildlife if recommended mitigative measures are implemented. Although serious accidents can damage portions of the aquatic habitat, extensive or widespread damage of entire river systems as a direct or indirect result of timber management is extremely unlikely.

Terrestrial Animals

Short term use of the land for timber production will not, as a rule, impair long term productivity for terrestrial wildlife. Removal of dense old-growth forests and restoration of new forests with more open conditions will even enhance yields of wildlife forage in many cases. An exception to the rule involves endangered species, where normally short term impacts such as the accidental disturbance or destruction of habitat could exterminate the only remaining population.

Ecological Interrelationships

The productivity of an impacted area will be significantly reduced in those instances where permanent structures, primarily roads, are constructed, bare rock is exposed or unstable soil conditions exist. The practices associated with the growing and harvesting of a timber crop increase the yield of vegetal material and some other environmental components beyond what nature alone can produce. The continual removal of this nutrient-containing resource over successive rotations and the practices to which the land is subjected may have a dampening effect on soil productivity over time. Such reduction of productivity can be offset by artificially introduced nutrients through fertilization.

Human Values

Health and Safety. With the exception of timber related employee accidents and accidents between the public and logging vehicles, there should be no long term effects associated with the timber management program.

Mineral Development. Timber management actions will have no significant long term effect on mineral development.

Wilderness. Assuming that natural or wilderness areas are recognized and classified accordingly, there will be no long term impact of the timber management program.

Recreation. The effects of the timber management program will not seriously impair future recreational values.

Grazing. The timber management program may eventually cause a reduction in numbers of livestock using forest ranges. However, the impact on the national forage requirement will be insignificant.

Agriculture. There should be no long term effects on agricultural crops or irrigation systems as a result of practices associated with timber management.

Commercial, Residential and Industrial. No impacts on long term productivity or potential for the development of these types of facilities are envisioned.

Local Government and Public Services. As long as timber management activities continue, some long term effects will be felt by state and local highway departments in the way of increased road maintenance and related costs.

Aesthetics. The program should have no long term effects on aesthetics.

Geology. Any impact that obliterates or substantially alters unique geologic features would decrease their human interest values.

Archeology. Accidental destruction or damage to archeological sites caused by the timber management program would have severe impacts on their values.

History. Inadvertent destruction or damage to historic sites would have long term impacts if the sites were not restored. Even with restoration, there would be some diminution in historic value.

F. Irreversible and Irretrievable Commitments of Resources

This section is focused on identifying the long term impacts of the timber management program from the perspective of irrevocable depletion of resources due to such causes as resource extraction, massive erosion, destruction of human interest values, elimination of endangered species and their habitat, and irreversible changes in land use. The consideration of any of these consequences is based only upon the existence of risks residual after mitigating measures have been employed.

Air

Under extreme conditions, natural restoration of the original micro-climate may take a long time, but there is no irretrievable commitment to any fixed micro-climate.

Land

Erosive processes induced by removal of the vegetative cover and the construction of roads produce an indeterminable amount of localized mass wasting which cannot be reversed or retrieved, no matter what mitigating measures are taken. When the vegetal cover is removed from an area where steep slopes occur and there is an abundant supply of moisture, the erosional process will sustain itself and in those situations where rock types and structure are conducive to weathering the erosional rates will increase. Natural erosion tends toward an equilibrium over geologic time. However, in terms of the human life span, erosion caused by man's activities results in an imbalance.

The irreversible impact and commitment of the soil resource is closely correlated to the physiographic and geologic factors described in the previous part. There are additional impacts, however, if the assumption is made that permanent roads will remain in perpetuity. In this case, approximately five percent of the land area will be committed to a relatively irreversible use, although the trend towards logging systems which require less roads would reduce these percentages in the future. This percentage does not include those areas in landslides. Furthermore, the soil, rock, gravel and other materials used to construct the roads and structures could also be viewed as representing a form of depletion and a permanent commitment of resources. In a theoretical sense, however, roads could be abandoned, and the areas returned to a lesser productive state if society should deem it necessary.

Water

Watershed values of a drainage are irretrievably committed, to a degree, in those instances where bare rock has been exposed or areas of bare rock enlarged as a result of massive soil movements. Landslides can also cause the destruction of a natural stream channel, resulting in its rechannelization and the accompanying permanent loss of soil and other materials.

Aquatic Vegetation

The natural process of the conversion of standing water habitats to land masses is accelerated by those timber management practices that contribute to sedimentation.

Terrestrial Vegetation

There are no known irreversible or irretrievable impacts of timber management on vegetation. Even where drastic misapplications may occur and result in extensive delays in tree regeneration, natural plan succession and technical progress can be expected to restore the site to a forest condition. Only where landslides expose rock surfaces can the forest condition be considered irretrievable.

Aquatic Animals

The most vulnerable aquatic animals are the rare fishes and aquatic animals, the populations of which could be severely damaged and possibly exterminated for an entire river system as a result of a timber management related accident.

Terrestrial Animals

Any loss of an endangered species constitutes a potential irreversible and irretrievable commitment. Small, non-mobile species with limited habitats and only local distributions, e.g., the Larch Mountain salamander, are especially vulnerable. Other more mobile species with widespread distribution, e.g., the spotted owl, could possible be eliminated from a specific area for a long period of time.

Ecological Interrelationships

Certain components of the biotic community and physical environment, such as endangered species, would represent irretrievable losses, if annihilated as a result of some catastrophic event. However, the basic ecological processes would probably recover and continue. Occasional situations occur in which the natural balance has obviously been damaged beyond repair. One example is the exposure of bedrock by mass soil movement, where restoration of a life-sustaining abiotic environment can be accomplished only by natural processes operating over a period of geologic time. However, the incidence of such occurrences and amount of land so affected would be minimal. The greatest risk of irretrievable impacts on the ecosystem resulting from soil erosion following the loss of vegetal cover exists in the fragile areas of the upper and lower limits of the Montane Forest. It should be pointed out that much remains unknown regarding the ecological interrelationships that exist throughout the Coniferous Forest Biome. Therefore, there may be irreversible impacts that are not presently recognized.

Human Values

Health and Safety. Timber related employee accidents that cause permanent injury or death are, of course, irreversible and irretrievable. This also applies to members of the public injured or killed in accidents involving log trucks or other equipment.

Mineral Development. Common varieties of minerals may be excluded from development to protect valuable forest sites.

Wilderness. Existing de facto wilderness areas should not be committed to the timber management program without careful consideration of the balance of values. Otherwise, important wilderness resources may be irrevocably lost.

Recreation. The timber management program commits no recreational values to irrevocable loss or degradation.

Grazing. Some extensive areas of forest range may be committed to timber production.

Agriculture. Accidental loss of soil caused by timber management activities can be considered irretrievable.

Commercial, Residential and Industrial. There should be no irreversible and irretrievable loss of lands for these uses, either on BLM lands or adjacent non-Federal lands.

Local Government and Public Services. There are no known irreversible and irretrievable commitments of resources.

Aesthetics. The long term impact of the timber management program on aesthetics cannot be described without specifying the parameters involved. Inasmuch as outstanding or unique areas have been removed from the timber management program, and other areas of special scenic interest may be protected by restrictions on what timber management practices may occur, then it may be stated that timber management activities will have no impact on the remaining lands. On the other hand, if the sight of a recent clear-cut anywhere in a large stand of virgin old-growth offends the viewer, then from his standpoint an irretrievable commitment of resources has been made to the detriment of aesthetics.

Geology. Accidental damage or destruction of geologic sites would, within the time frame of man's interest, be irreversible and irretrievable.

Archeology. Inadvertent damage or destruction of archeological sites would probably be irreversible and irretrievable. Provided sites were not completely destroyed, enough salvage might be possible to retain their human interest value.

History. Conceivably all historic sites that are the works of man could be restored should they be destroyed. However, their values would be diminished and, in effect, the values lost irretrievably.

IV. PERSONS, GROUPS, AND GOVERNMENT AGENCIES CONSULTED

The Bureau's western Oregon timber management program is the product of a broad array of expertise. At the outset, the program must be compatible with the Bureau Planning System. Under this system the Management Framework Plan, which sets constraints for the program, is routinely exposed to public input during its development.

As the program is implemented, it is subjected to a continuous process of monitoring, and improvement by input from both Bureau and external sources. BLM's Western Oregon Research Committee meets quarterly to assess proposals for timber management research. Selected research projects are assigned to the Pacific Northwest Forest and Range Experiment Station and to Oregon State University. The findings of such research are applied to the practical solution of specific problems or to the improvement of timber management practices.

The current Allowable Cut Plan, which sets the level of harvest and specifies the cultural practices to be used, underwent thorough public review prior to its implementation in 1970.

The Annual Timber Sale Plan is an essential part of the Bureau's blueprint for timber harvesting. When a tentative sale plan has been developed at the district level, its first exposure to an outside group usually occurs with its presentation to the district advisory board. Since this board represents all known interests in the locality, its reaction is valuable in identifying areas of unusual public interest in the plan.

After review by the district advisory board and approval by the State Director, the Annual Timber Sale Plan is normally sent to all parties on the district mailing list. The mailing list is open to anyone interested in the program. It usually includes individuals, public interest groups, conservation-oriented organizations and units of local government, as well as timber industry representation. Detailed information on any of the sale plan tracts is available to the public on request at the district office.

The BLM State Office distributes copies of all district sale plans to the State of Oregon's clearinghouse, where the plans are reviewed to determine how they will mesh with the programs of other governmental agencies and planning entities.

The Bureau's western Oregon timber management program has been exposed to public scrutiny since its inception. Broad aspects of the program, such as timber sale plans and distribution of receipts to counties, are given general coverage by the various news media. Individual actions associated with the program (e.g., reforestation activities, road construction projects and unusual logging operations) may be publicized locally.

V. INTENSITY OF PUBLIC INTEREST

Because of the revenue sharing provisions of the O&C Act, there is a continuing interest in BLM's timber management program on the part of the western Oregon counties. Other segments of the public have been interested more sporadically, usually in reaction to particular situations that have been publicized by the news media.

As one example of this there was, a few years ago, a well-publicized controversy regarding the proposed exchange of some BLM-administered lands in southwestern Oregon for private lands in the vicinity of Point Reyes, California. At that time, the Oregon forest industries adamantly opposed the exchange on the grounds that it would disrupt the BLM timber management program and reduce the volume of federal timber offered for sale. There is no reason to believe that this attitude has changed.

Another example of reaction to a particular situation occurred after the Secretary's announcement, on May 6, 1970, of the Bureau's present Allowable Cut Plan for western Oregon. Governor McCall's concern for the uncertain impacts of the new plan prompted him to create an ad hoc body, the Oregon Forest Resources Commission, to study, evaluate and report on the plan.

Environmental groups have not strongly opposed the Bureau's timber management program so far, although there is some evidence that this kind of opposition may be increasing.

On balance, the western Oregon timber management program seems to be generally well accepted and relatively non-controversial.

VI. PARTICIPATING AGENCY STAFF

This EAR incorporates abstracts and excerpts from two BLM preliminary draft programmatic environmental impact statements -- Timber Management, and Onshore Oil and Gas Leasing in Oregon. The following individuals authored material borrowed from these parent documents.

Karl Bergsvik, Forester, WO
Robert L. Borovicka, Fishery Biologist, OSO
Edward R. Burroughs, Hydrologist, OSO
Ronald J. Cole, Civil Engineer, OSO
Dean Delavan, Geologist, OSO
Ira D. Luman, Wildlife Management Specialist, OSO
Arthur L. Oakley, Fishery Biologist, OSO
Bruce A. Powers, Planner, WO
Reginald A. Ross, Range Conservationist, OSO
Richard E. Schroeder, Forester, OSO
Byron R. Thomas, Soil Scientist, OSO
Charles L. Thomas, Forester, OSO

Editing and conjunctive writing were done by Ronald R. Salder, Program Analyst, and Marietta Vergeer, Geographer, both OSO.

VII. RECOMMENDATION ON ENVIRONMENTAL STATEMENT

A Bureau-wide programmatic environmental impact statement, Timber Management, has been prepared and is presently involved in the formal review process. The programmatic EIS describes and evaluates timber management practices and associated environmental impacts. While these impacts are found to be significant, the EIS concludes that, properly mitigated, they are acceptable. The findings of this EAR for western Oregon support the conclusions of the Bureau-wide EIS.

Considering these facts, and the relatively low level of controversy presently involved, it is recommended that no environmental impact statement be prepared for the western Oregon timber management program at this time. This EAR could serve as the basis for an ~~EAR,~~ EIS, should one be deemed necessary at some future time.

As stated in the Preface, supplemental analyses are prepared for the individual actions which implement the timber management program. It is conceivable that the EAR for an individual proposal (e.g., timber sale, development action) may project residual environmental impacts which differ substantially from those anticipated in this programmatic analysis. Likewise, an individual action may generate an unusual degree of public controversy. Such abnormal circumstances may indicate that a formal environmental impact statement is essential for an individual proposal.

VIII. SIGNATURE DATE

Archie D. Craft
State Director

May 10, 1974

ADDENDA:

Environmental Analysis Worksheets

Timber Management Practices Index

KEY TO SYMBOLS USED ON ENVIRONMENTAL
ANALYSIS WORKSHEETS

Symbol	Meaning
L	low impact
M	medium impact
H	high impact
+	beneficial impact
-	adverse impact
0	no impact
X	type and degree of impact unknown

ENVIRONMENTAL ANALYSIS WORKSHEET

Remarks: ______________________________

HARVEST

STAGES OF IMPLEMENTATION	Intermed. Skidding			Final Harvest				Ground Skidding					Aerial Skidding			
DISCRETE OPERATIONS	1A	1B	1C	2A	2B	2C	2D	3A	3B	3C	3D	3E	4A	4B	4C	
I. NON-LIVING COMPONENTS																
A. AIR																
Air Movement Patterns	0	0	L	M	M	L	L	0	0	0	0	0	0	0	0	
Temperature	L	0	L	M	M	L	L	0	0	0	0	0	0	0	0	
Particulate Matter	0	0	0	0	0	0	0	0	-L	-L	-L	-L	-L	-L	-L	
B. LAND																
Soil Depth	0	0	0	0	0	0	0	0	X	L	L	L	0	0	0	
Soil Structure	0	0	0	0	0	0	X	-M	-H	-M	-M	X	-L	-L	X	
Soil Nutrients	0	0	X	L	L	X	L	+L	0	0	0	0	0	0	C	
Soil Erosion	0	0	0	-M	-M	-L	L	-M	-H	-M	-M	X	-L	-L	X	
C. WATER																
Sediment Load	0	0	0	-M	-L	0	X	0	M	L	L	L	X	X	X	
Dissolved Solids	0	0	0	X	X	0	X	0	X	X	X	X	X	X	X	
Nutrients	X	0	X	X	X	X	X	L	0	0	0	0	0	0	X	
Solid Debris	X	0	X	-L	-L	0	X	0	0	L	L	X	0	0	X	
Dissolved Oxygen	0	0	0	X	X	0	0	0	0	L	L	X	0	0	X	
Temperature	0	0	0	X	X	0	X	0	0	X	X	X	X	X	X	
II. LIVING COMPONENTS																
A. PLANTS (AQUATIC)	0	0	0	-L	-L	X	X	0	M	X	X	X	X	X	X	
B. PLANTS (TERRESTRIAL)																
Grasses	+L	X	+L	+M	+M	L	X	0	L	L	L	L	L	L	X	
Shrubs	+L	X	+L	+M	+M	X	X	0	L	M	M	X	M	M	L	
Conifers	+L	X	-L	+M	+M	L	M	0	L	H	H	X	X	X	X	
Broadleaf Trees	-M	0	-M	+M	+M	L	X	0	L	H	H	X	X	X	X	
C. ANIMALS (AQUATIC)																
Fish	0	0	0	-M	-M	L	L	0	X	L	L	L	X	X	0	
Invertebrates	0	0	0	X	X	X	X	0	X	X	X	X	X	X	0	
Zoo Plankton	0	0	0	X	X	X	X	0	X	X	X	X	X	X	0	
D. ANIMALS (TERRESTRIAL)																
Mammals	X	X	X	X	X	X	X	0	M	M	M	M	M	M	X	
Birds	X	X	X	X	X	X	X	+L	X	X	X	X	X	X	X	
Reptiles	X	X	X	X	X	X	X	0	X	X	X	X	X	X	X	
III. ECOLOGICAL INTERRELATIONSHIP																
A. ECOLOGICAL PROCESSES																
Succession	X	0	M	H	H	L	L	0	M	M	M	M	L	L	L	
Food Relationships	X	0	X	X	X	X	X	0	X	X	X	X	X	X	X	
Community Relationships	X	0	X	X	X	X	X	0	X	X	X	X	X	X	X	
IV. HUMAN VALUES																
A. LANDSCAPE CHARACTER	L	0	L	H	H	L	L	0	H	H	H	H	L	L	L	
B. SOCIOCULTURAL INTERESTS	0	0	0	X	X	L	X	L	M	L	L	L	X	X	X	

Remarks: ______________________________

HARVEST (Page 2)

STAGES OF IMPLEMENTATION	Road Construction						Road Maintenance			
DISCRETE OPERATIONS	5A	5B	5C	5D	5E	5F	6A	6B	6C	6D
I. NON-LIVING COMPONENTS										
A. AIR										
Air Movement Patterns	0	0	0	0	0	0	0	0	0	0
Temperature	-M	0	0	0	0	0	0	0	0	0
Particulate Matter	-L	-L	-L	-L	-L	0	-L	-L	0	0
B. LAND										
Soil Depth	L	H	H	0	0	0	0	0	0	0
Soil Structure	L	H	H	0	0	0	0	0	0	0
Soil Nutrients	X	X	X	0	0	0	0	0	0	0
Soil Erosion	L	H	H	0	0	0	0	X	0	0
C. WATER										
Sediment Load	L	H	H	L	+L	+L	X	X	X	0
Dissolved Solids	L	X	X	0	0	0	0	0	0	0
Nutrients	X	X	X	0	0	0	0	X	0	0
Solid Debris	L	H	H	0	0	0	X	0	X	0
Dissolved Oxygen	X	X	X	0	0	0	0	0	0	0
Temperature	X	X	X	0	0	0	0	0	0	0
II. LIVING COMPONENTS										
A. PLANTS (AQUATIC)	X	X	X	0	0	0	0	0	0	0
B. PLANTS (TERRESTRIAL)										
Grasses	M	H	H	0	0	0	0	M	0	0
Shrubs	H	H	H	0	0	0	0	M	0	0
Conifers	H	H	H	0	0	0	0	0	0	0
Broadleaf Trees	H	H	H	0	0	0	0	0	0	0
C. ANIMALS (AQUATIC)										
Fish	X	X	X	0	0	+M	0	0	+L	0
Invertebrates	X	X	X	0	0	X	0	0	0	0
Zoo Plankton	X	X	X	0	0	X	0	0	0	0
D. ANIMALS (TERRESTRIAL)										
Mammals	L	L	L	0	0	0	0	0	0	0
Birds	L	X	X	0	0	0	0	0	0	0
Reptiles	X	X	X	0	0	0	0	0	0	0
III. ECOLOGICAL INTERRELATIONSHIP										
A. ECOLOGICAL PROCESSES										
Succession	H	H	H	0	0	0	0	L	0	0
Food Relationships	H	H	H	0	0	0	0	X	0	0
Community Relationships	H	H	H	0	0	0	0	0	0	0
IV. HUMAN VALUES										
A. LANDSCAPE CHARACTER	H	H	H	L	L	0	0	X	0	0
B. SOCIOCULTURAL INTERESTS	X	H	H	X	X	0	0	0	X	H

ENVIRONMENTAL ANALYSIS WORKSHEET

Remarks: ______________________________

DEVELOPMENT

STAGES OF IMPLEMENTATION														
DISCRETE OPERATIONS	7A	7B	7C	7D	7E	7F	7G	7H	7I	7J	7K	7L	7M	7N
I. NON-LIVING COMPONENTS														
A. AIR														
Air Movement Patterns	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Temperature	0	0	X	0	X	0	0	0	0	X	X	X	0	0
Particulate Matter	0	L	X	L	-L	-L	-L	-L	0	0	0	X	0	0
B. LAND														
Soil Depth	0	L	0	X	X	0	L	0	0	0	0	0	0	0
Soil Structure	0	L	X	X	X	0	0	0	0	0	0	0	0	0
Soil Nutrient	0	L	+L	X	-M	-L	0	X	X	0	0	X	X	0
Soil Erosion	0	-M	X	X	-L	-L	X	+L	0	+L	+L	X	0	0
C. WATER														
Sediment Load	0	M	0	X	X	0	0	0	0	0	X	X	0	0
Dissolved Solids	0	X	0	0	X	0	0	X	0	0	0	0	X	0
Nutrients	0	X	0	0	X	X	0	X	0	0	0	X	0	0
Solid Debris	0	L	L	X	0	0	0	0	0	0	0	0	0	0
Dissolved Oxygen	0	X	X	0	X	0	0	0	0	0	0	0	0	0
Temperature	0	0	X	0	X	0	0	0	0	0	0	0	0	0
II. LIVING COMPONENTS														
A. PLANTS (AQUATIC)	0	0	0	0	X	0	0	0	0	0	0	X	X	0
B. PLANTS (TERRESTRIAL)														
Grasses	0	H	0	0	X	X	X	X	X	0	X	H	0	0
Shrubs	0	H	H	M	X	X	X	X	X	0	X	X	0	0
Conifers	M	X	0	X	X	X	X	X	0	+H	X	0	0	0
Broadleaf Trees	0	H	X	X	X	X	X	X	0	0	X	X	0	0
C. ANIMALS (AQUATIC)														
Fish	0	X	0	0	X	0	0	0	0	0	0	X	0	0
Invertebrates	0	X	0	0	X	0	0	0	0	0	0	X	0	0
Zoo Plankton	0	X	0	0	X	0	0	0	0	0	0	X	0	0
D. ANIMALS (TERRESTRIAL)														
Mammals	0	X	M	L	X	0	0	X	0	X	X	X	X	H
Birds	0	X	X	X	X	0	0	X	0	X	0	X	X	0
Reptiles	0	X	X	X	X	0	0	X	0	0	0	X	X	0
III. ECOLOGICAL INTERRELATIONSHIP														
A. ECOLOGICAL PROCESSES														
Succession	L	M	L	L	X	0	0	X	X	X	X	X	X	X
Food Relationships	0	M	X	L	X	0	0	X	0	0	X	X	X	X
Community Relationships	0	M	X	L	X	0	0	X	0	0	X	X	X	X
IV. HUMAN VALUES														
A. LANDSCAPE CHARACTER	0	H	L	L	H	L	L	0	X	X	X	M	0	X
B. SOCIOCULTURAL INTERESTS	L	X	0	0	X	0	0	0	0	X	X	X	H	X

ENVIRONMENTAL ANALYSIS WORKSHEET

Remarks: ______________________________

DEVELOPMENT (Page 2)

STAGES OF IMPLEMENTATION															
DISCRETE OPERATIONS	7O	7P	7Q	7R	7S										
I. NON-LIVING COMPONENTS															
A. AIR															
Air Movement Patterns	0	0	0	X	0										
Temperature	0	0	0	+L	0										
Particulate Matter	0	0	0	0	0										
B. LAND															
Soil Depth	0	0	0	0	0										
Soil Structure	0	0	0	0	0										
Soil Nutrient	X	0	+M	X	X										
Soil Erosion	+L	0	+L	0	0										
C. WATER															
Sediment Load	0	0	0	0	0										
Dissolved Solids	0	0	X	0	0										
Nutrients	0	0	X	0	0										
Solid Debris	0	0	0	0	0										
Dissolved Oxygen	0	0	0	0	0										
Temperature	0	0	0	0	0										
II. LIVING COMPONENTS															
A. PLANTS (AQUATIC)	0	0	X	0	0										
B. PLANTS (TERRESTRIAL)															
Grasses	X	0	X	X	0										
Shrubs	X	0	X	X	0										
Conifers	X	0	X	X	X										
Broadleaf Trees	X	0	X	X	0										
C. ANIMALS (AQUATIC)															
Fish	0	0	X	0	0										
Invertebrates	0	0	0	0	0										
Zoo Plankton	0	0	0	0	0										
D. ANIMALS (TERRESTRIAL)															
Mammals	X	X	X	X	0										
Birds	0	X	X	X	0										
Reptiles	0	X	X	0	0										
III. ECOLOGICAL INTERRELATIONSHIP															
A. ECOLOGICAL PROCESSES															
Succession	X	0	0	0	0										
Food Relationships	0	0	X	X	0										
Community Relationships	0	X	X	X	0										
IV. HUMAN VALUES															
A. LANDSCAPE CHARACTER	X	0	0	0	0										
B. SOCIOCULTURAL INTERESTS	X	0	X	0	0										

ENVIRONMENTAL ANALYSIS WORKSHEET

Remarks: ______________________________

P R O T E C T I O N

STAGES OF IMPLEMENTATION	Insects				Disease	
DISCRETE OPERATIONS	8A	8B	8C	8D	9A	9B
I. NON-LIVING COMPONENTS						
A. AIR						
Air Movement Patterns	0	0	0	0	0	0
Temperature	X	X	0	0	X	X
Particulate Matter	0	0	X	0	0	0
B. LAND						
Soil Depth	0	0	0	0	0	0
Soil Structure	0	0	X	0	0	0
Soil Nutrients	0	0	X	0	0	X
Soil Erosion	0	0	X	0	0	0
C. WATER						
Sediment Load	0	0	X	0	0	0
Dissolved Solids	0	0	X	0	0	0
Nutrients	0	0	X	0	0	0
Solid Debris	0	0	0	0	0	0
Dissolved Oxygen	0	0	0	0	0	0
Temperature	0	0	0	0	0	0
II. LIVING COMPONENTS						
A. PLANTS (AQUATIC)	0	0	X	0	0	0
B. PLANTS (TERRESTRIAL)						
Grasses	0	0	X	0	0	0
Shrubs	0	0	X	0	0	0
Conifers	X	X	X	X	X	X
Broadleaf Trees	X	X	X	0	0	0
C. ANIMALS (AQUATIC)						
Fish	0	0	X	X	0	0
Invertebrates	0	0	X	X	0	0
Zoo Plankton	0	0	X	X	0	0
D. ANIMALS (TERRESTRIAL)						
Mammals	X	X	X	0	X	X
Birds	X	X	X	0	X	X
Reptiles	X	X	X	0	X	X
III. ECOLOGICAL INTERRELATIONSHIP						
A. ECOLOGICAL PROCESSES						
Succession	X	X	X	0	X	X
Food Relationships	X	X	X	0	X	X
Community Relationships	X	X	X	0	X	X
IV. HUMAN VALUES						
A. LANDSCAPE CHARACTER	X	X	X	0	0	0
B. SOCIOCULTURAL INTERESTS	X	X	X	0	X	X

INDEX TO TIMBER MANAGEMENT PRACTICES